Textile quality assurance: a comparison between education and industry

Sandra Flora Chisholm
Iowa State University

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INTRODUCTION

During this period of increasing foreign competition, the production of quality products is particularly important to apparel manufacturers in the United States. Consumers continue to place more value on quality and are willing to pay higher prices for quality goods (Redman, Chiappina, & Clausen 1994; Ryan, 1988; U.S. Industrial Outlook, 1994). Thus, quality is increasingly important in maintaining a viable U.S. apparel industry.

Commonly accepted as one of the most important issues in business today, quality has been defined in many different ways. The American Society for Quality Control defines quality as "the totality of features and characteristics of a product (or service) that bears on its ability to satisfy stated or implied needs" (ANSI/ASQC, 1987 p. 2). According to W. Edwards Deming "quality is pride of workmanship," and improved quality leads to increased productivity and decreased costs (Aguayo, 1990, p. xi). Deming proposed that quality is obtained through management's commitment to and involvement in continually improving quality. He states that quality products are achieved by continually improving and learning about the process that creates these products, and not by inspection of the final product when it is too late and costly to correct mistakes. Good relationships and partnerships with suppliers are also vital to a business that is committed to quality (Aguayo, 1990; Deming, 1982).

In order to remain competitive, many apparel manufacturers have recognized the need to raise the quality of their products and deliver goods that consumers want in a timely manner. Companies have invested in new technologies which increase automation throughout the garment production process, thus reducing some of the human variability that is inevitable in a labor intensive process. Advancements in spreading technology and computerized pattern grading and marking can reduce the possibility of sizing errors, contribute to reducing
variability, and produce more consistency. All of these factors can increase quality in terms of sizing, fit, and overall garment appearance for the consumer (Mehta, 1992).

Many manufacturers make use of networked communication systems. Electronic data interchange (EDI) enables manufacturers to respond quickly to consumers' changing demands. By expediting communication with retailers and raw materials producers via networked computer systems, manufacturers can be more responsive to consumer demands resulting in a shorter lead time from raw materials to finished product. EDI also allows manufacturers to communicate clearly their needs to suppliers in terms of quality, and promotes partnerships between suppliers, manufacturers, and retailers (Hunter, 1990).

The future of the U.S. apparel industry will depend on its ability to use these advancements to gain competitive advantage in the global marketplace (U.S. Industrial Outlook, 1993). A 1987 American Society for Quality Control (ASQC)/Gallup survey of corporate executives highlighted the importance of quality in terms of competitive advantage, and found that 88% of executives thought that improving quality played an important part for U.S. companies to compete in a global market. However, the author concluded that although most respondents recognized the importance of quality, they were not doing what was needed to achieve it (Ryan, 1987).

Consumers seem to agree with Ryan. According to an ASQC/Gallup survey of consumers in 1985 and another in 1988, attempts of U.S. manufacturers to improve quality have gone unnoticed by consumers. Respondents to the 1988 survey reported more problems due to poor quality goods than those responding to the 1985 survey (Ryan, 1988). This may be due to a decline in quality or an increase in consumers' expectations of quality. Industry experts believe that if the apparel industry is going to survive in global competition it must produce goods that are identifiably superior in quality to foreign imports. Consumers
and retail buyers must be able to identify superior quality before they will be prepared to spend more money on domestically produced goods (Kolbeck, 1984).

The organization of the quality function in U.S. industries began in the early 1900s as an extension of the production foreman's responsibilities, and has evolved gradually in a series of steps to reach what may be known as the quality assurance department. The quality assurance function differs from the earlier quality functions in that it is not part of production, rather the quality assurance department is a separate function which includes responsibilities in product development, manufacturing, customer support, and administration. Kolbeck (1984) presented a timeline of the quality function organization and suggested that early organizations were ineffective because they present a conflict of interest between the quality and the quantity of products produced. He proposed a model of functions under the quality assurance department (See Figure 1) and concluded that if the apparel industry is using any quality structures other than this quality assurance model, their program cannot be effective.

Figure 1. Functions under the quality assurance department (Kolbeck, 1984)
The apparel industry, like many other industries, has experienced changes in recent years. Organizational structures have changed and the use of technology has altered business practices. However, quality assurance programs have not changed at the same pace. Inspection is a method used to ensure quality in apparel goods and may be carried out at various stages in apparel production: raw material inspection, in-process inspection, and final or post production inspection. Post production inspection procedures for determining quality remain most prevalent in the apparel industry. Inspection may be accomplished in several ways. In 100% inspection, every item is inspected and a decision is made to accept or reject each item. In spot checking, selected production runs/shipments are inspected. Finally in acceptance sampling or statistical sampling, a sample can be taken to represent a certain proportion of a production lot or shipment. A lot is accepted or rejected based on 100% inspection of a random sample drawn from the lot. This method is commonly used in apparel firms. Acceptance sampling differs from statistical process control since it is executed after the products are completed, whereas statistical process control methods are used as the goods are produced. Post production inspection methods are thought by quality experts to cause problems because they emphasize detection rather than prevention or improvement and are therefore costly to the company. There is a need for the apparel industry to improve quality assessment throughout the production process. Quality improvement should begin with raw materials and continue throughout the process allowing for more employee involvement and empowerment (Karnes & Kanet, 1994; Kolbeck, 1984; Mehta, 1992; Pond, 1994).

Knapton (1990) proposed that quality can be improved by a knowledge of the costs of poor quality to a company. The apparel industry accepts mistakes in the form of reworks, repairs, irregulars, and consumer returns as normal, and usually measures quality costs in terms of cost to repair defective garments. Quality could be measured in terms of the dollar amount lost by the manufacturer in addition to losses due to the sale of seconds and labor
costs to repair defective items. If costs were attached to each internal failure, a monthly or weekly price could be attached to poor quality. This would, in turn, identify a need for quality improvement and highlight the areas and operations that would gain most from quality improvement. Knapton states that in order for integrated quality improvement to occur, data must be shared among suppliers and customers; he concludes that business environment and management commitment are crucial factors (American Apparel Manufacturers Association, 1994; Knapton, 1990).

Throughout the literature the importance of creating a corporate quality culture has been emphasized (Rubinstein, 1991; Ryan 1987; Saraph & Sebastian, 1993). An organization's culture influences the organizational beliefs, interrelationships, and interactions of its employees, which has an impact on how they work together and how the organization interacts with the outside environment (American Supplier Institute, 1990). Organizational culture is embedded within the organization, therefore culture changes must be integrated within the system, and quality goals and philosophies should become part of the organization's mission. Making changes to an existing corporate culture is extremely difficult, thus management dedication to continuous quality improvement is required before a quality improvement program will be successful (Saraph & Sebastian, 1993). In addition to corporate culture, the stage at which quality is addressed in the process is important.

Quality should be built into a product from conception to the finished and delivered product. Boznak (1994) suggests that more emphasis should be made in defining products with detailed specifications in a timely manner to minimize changes further in the product development and manufacturing process. Boznak presented "The Nature of Productivity Empowerment" model, which describes that "efficiency of a product's development is directly influenced by the adequacy and integrity of its definition" (Boznak, 1994, p.75). He
highlights the importance of predevelopment and understanding of the target customer's needs before a product is developed.

In the same way that quality should be built into a product in the manufacturing arena it should also be built in an educational setting. If we assume that students of quality assurance are the products of a quality assurance class and employers in the apparel industry are the consumers, then the content of the course and the way that it is taught are critical factors in satisfying the consumers' needs. To be able to do this, the needs of prospective employers in industry must be made known, and a comprehensive knowledge of quality assurance practices in industry should be identified (Fusco, 1994).

The literature has highlighted quality problems that exist in the U.S. apparel industry and the changes that are required for the industry to remain competitive. Even though many articles identifying problems exist, only one recent article could be found that addresses current quality assurance practices in the apparel industry, and no comprehensive study of academic practices was found. If changes are being made regarding quality assurance practices in the apparel industry, it seems reasonable to assume that these changes should be extended to include the content of textile quality assurance courses in academia.

**Purpose**

The purpose of this study is to explore current quality assurance practices in the apparel industry, study the content of quality assurance classes in academia, and compare the two so that major differences can be identified. Kolbeck's model of functions under the quality assurance department (Figure 1) will be used as the basis for comparison of quality assurance functions. Kolbeck (1984) outlined the organization of quality assurance as a separate function that is involved in product development, manufacturing, customer support, and administration.
Glock & Kunz (1995) proposed a taxonomy of the apparel merchandising system. Within that taxonomy, quality is addressed in line development (preadoption product development and postadoption product development), business plan, and sourcing strategy (materials and production). This taxonomy highlights how quality is integrated within the merchandising function. The "Taxonomy of the apparel merchandising system (TAMS)" is used to demonstrate quality integration within the merchandising and product development function of the companies studied.

Definition of Terms

Acceptance Sampling: "to either accept or reject a lot based on a representative sample from the lot. Each piece in the sample is checked for conformance to a particular quality characteristic or to several quality characteristics" (Pond, 1994, p.8).

Apparel Quality: A combination of performance, features, reliability, conformance, durability, aesthetics, and perceived quality that make a product usable to the consumer of the product (Garvin, 1984; Mehta, 1992).

Corporate Quality Culture: Values regarding organizational quality goals possessed by employees and management throughout an organization (Saraph & Sebastian, 1993).

Electronic Data Interchange: The rapid transfer of information backwards and forwards throughout the apparel pipeline via computerized networks (Hunter, 1990).

Product Development: "Design and engineering required to make products serviceable, producable, salable, and profitable" (Glock & Kunz, 1990 p. 521).

Quality Assurance: "A quality function that not only works in the development stages of product development and the inspection of the products during the manufacturing cycle, but also audits the performance of its own functions to ensure that the quality level is maintained through vigilance of all areas of the quality function." (Kolbeck, 1984, pp. 87 - 88).
Objectives

1. Identify current quality assurance practices from a selected sample of manufacturing firms in the United States apparel industry.

2. Identify commonalties and differences in quality practices throughout the companies sampled.

3. Identify the content of a selected sample of quality assurance/textile testing courses in the United States.

4. Compare the results of apparel industry practices and content of quality assurance courses.

5. Identify components of a minimal total quality assurance program that would prepare students for industry positions in the apparel manufacturing segment.
REVIEW OF LITERATURE

The review of related literature is divided into four sections. I discuss quality management philosophies in the first section. In the second section, I review quality assurance practices in apparel manufacturing. In the third section I review the content of educational materials used in quality assurance and textile testing classes in colleges. In the fourth and final section I address educational literature related to the relationships existing between education and industry. A chapter summary concludes the chapter.

Quality Management Philosophies

The philosophy of total quality management (TQM) is documented in the writings of quality gurus such as: W. Edwards Deming, Philip Crosby, and Joseph Juran. TQM is a management philosophy that presents a foundation for the continual improvement of quality within organizations. Under the TQM philosophy, everyone in the organization has responsibility for continually improving quality and meeting or exceeding customer requirements. The definition of quality within the TQM framework extends that of product quality. Under the TQM philosophy, the concept of quality includes all aspects of the organization (Aguayo, 1990). Critical to a successful total quality culture is management leadership. Management must be committed to continual improvement of quality and provide workers with the appropriate resources that will enable them to fulfill their responsibility to quality (Crosby, 1980). Quality should be built, not inspected, into a product. It is only through this method that costs will decrease and productivity will increase. The emphasis should be on the prevention, and not the detection, of errors (Badiru & Ayeni, 1993; Deming, 1982).
Quality

There are many definitions of quality in the literature. However, there is a central theme to be found in almost all of these definitions: the consumer. One aspect of quality is what the customer wants and expects from a product or service. Some aspects of quality are easily quantified: the characteristics of a seam, the yarn count of a fabric, or how many times the garment can be laundered before appearing unsightly. However, certain aspects of quality are not as easy to measure, like fit or style. It is not until multiple products are compared that lack of the un-measurable quality characteristics is noticed. This does not mean that the difference between two products indicates that one is of superior quality. The customer of each product must decide what characteristics determine better quality. The manufacturer of products must be aware of what the customer of that product perceives as good quality. Many apparel firms translate quality in terms of customer requirements to quality in the product by means of product specifications and tolerances. These specifications may define quality for each product in the apparel firm. Therefore, in the apparel industry quality is often defined as conformance to specifications or standards (Aguayo, 1990, Garvin, 1984, 1987; Glock & Kunz, 1995).

Modern technology allows manufacturers to produce goods with superior performance characteristics. However, for a product to be of superior quality it must perform well according to multiple variables. Modern technology such as computer aided design, computerized pattern grading, and automated cutting technology can improve some of the variables of a product and the consistency of the product, but will not guarantee superior quality in the eyes of the consumer. An example of this is the use of high performance fabric in making protective clothing. The fabric may prevent exposure to the most extreme conditions, but the product will satisfy consumers only if it has been designed correctly to account for comfort, fit, and manual dexterity on the job (Aguayo, 1990). While improved
technology has numerous advantages, it cannot be relied upon solely to improve quality. Technology can be an element of a management strategy to improve quality, but not the only element (Gilbert, 1987; Rao, 1985).

Approaches to Defining Quality

Garvin (1984, p. 25) presented "five approaches to defining quality: the transcendent approach, the product-based approach, the user-based approach, the manufacturing-based approach, and the value-based approach." The transcendent approach to quality suggests that quality cannot be defined and can be recognized only through experience. The product based approach views quality as quantifiable and measurable. The difference in quality of a product is directly related to a measurable characteristic of that product. An example in the apparel industry may be that of fabric; a high quality fabric may be defined as having a high number of yarns per square inch. This approach allows for the ranking of goods according to quantifiable characteristics. The user-based approach to quality takes into consideration the demands of individual consumers. Consumers regard quality goods as being those that best meet with their needs. Consumer needs vary considerably among target markets, and therefore this approach would not allow quality to be ranked according to quantifiable characteristics, but rather stratified among different target consumer groups.

The manufacturing-based approach to quality is more objective and relates to conformance to manufacturing and engineering specifications. This approach assumes that other approaches to quality, such as the product based or user based, have already been considered when setting specifications. The value-based approach to quality definition considers performance at a set price or value for money. This approach takes into consideration both the quality and price of the product. This approach recognizes that price is a variable in the consumer's perception of product quality. A consumer may appreciate the
quantifiable aspects of a product, such as high yarn count fabric, but may not feel that the extra cost is worth it.

These definitions of quality highlight the different meanings of quality that exist throughout the organization. These differing definitions of product quality highlight the potential for conflict between functions in an organization.

**Dimensions of Product Quality**

In a later article, Garvin (1987, p. 104) presented a framework for strategic analysis in the form of the "eight dimensions of quality: performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality." Garvin describes the dimensions of quality as being inversely correlated with each other. He states that "an improvement in one may be achieved only at the expense of another," and he claims that this "makes strategic quality management possible."

Performance of a product refers to measurable operating characteristics. An example in apparel may be absorbency or seam strength. All performance characteristics are not necessarily quality characteristics. Performance characteristics are perceived differently by consumers; however, some characteristics, such as appearance of seams, usually would be viewed as a quality characteristic (Garvin, 1987).

Features are defined by Garvin as the "bells and whistles" of products. An example in apparel may be a permanent press finish which would be a secondary performance feature, whereas a primary product feature would be the dimensional stability of the garment. Features may be considered as the total number of options available. For example, a manufacturer offers a large number of style and color combinations. Manufacturing flexibility may also be considered a quality characteristic. If a manufacturer can respond quickly to changes in consumer needs and is able to offer a wide variety of styles and colors year round, consumers may perceive these options as a quality characteristic (Garvin, 1987).
Reliability deals with the probability that a product will fail within a specified time period and require repair. For particular product categories and consumers, reliability is very important. Reliability in apparel items is more applicable to staple or durable items such as denim jeans or work wear that are usually repaired when they fail; time to failure would be considered a quality characteristic. Other apparel items, such as fashion products, are not usually repaired when they fail (Garvin, 1987).

Conformance refers to meeting standards and specifications. Specifications are usually written to include a target value and tolerance, which provides an acceptable range for characteristics. Problems can arise when one part in the process is on the lower end of the tolerance and a corresponding part is on the higher end of the tolerance. When these two parts come together, they may not fit. This is referred to as tolerance stack up. The specifications written for a product will determine the quality level of that product. Specifications are written according to the needs of a particular consumer and end-use. Depending upon the end-use and purpose of the product, satisfactory performance may be accomplished at different levels of quality. The philosophy of continual improvement aims to reduce the variation from target values even though the products are within specification. The goal of the process should be to maintain a normal curve which peaks at the target value. Process improvement aims to make the normal curve narrower with fewer items at extreme ends (Aguayo, 1990; Garvin, 1987; Glock & Kunz, 1995; Pond, 1994).

Durability refers to the expected lifetime of a product, and its physical usefulness or appearance for a specific use. For example, an aspect of durability may be the length of time before the knees are worn through in children's play wear to such an extent that there would be no economic advantage to repairing the product, and replacement is the best option. Durability and reliability are closely related. Durability in apparel items refers more to the
characteristics of a product that allow that product to perform well in its end use (Garvin, 1987).

Aesthetics is a subjective measure of how the product looks, feels, sounds, tastes, or smells (Garvin, 1987). This aspect of product quality is the most likely to change from consumer to consumer. Fashionability is one dimension of aesthetics in apparel items. Perceived quality is based primarily on a product's reputation and results because consumers rarely have complete information about products. Therefore, consumers often make comparisons between products based on indirect and incomplete information such as advertising images and brand names (Garvin, 1987). This framework provides eight different quality options available to companies. These options provide opportunities for companies to differentiate their products through quality (Garvin, 1987).

This review of quality management philosophies is not exhaustive of all documentation on this subject. However, several common themes prevail: support for proactive rather than reactive philosophies; building in rather than inspecting quality into a product; the important role of the customer; the role of technology, quality and productivity; organizational development and the role of management; statistical methods of process improvement; and the complexity of product quality.

Quality and Productivity

A common mis-perception of management is that superior quality will always mean higher costs. This mentality causes acceptable levels of nonperformance to be established based on an estimate of costs. Along with this attitude comes the management practice of setting the minimum level of quality lower than is necessary by setting an allowed level of defects in a product or a production lot instead of aiming for zero defects. Under this philosophy, once that minimum level of quality is reached, the job of quality is done. This philosophy does not support continual improvement (Aguayo, 1990).
Deming does not agree with this attitude. Rather, Deming believes that there is a positive correlation between quality and productivity. Increasing quality reduces costs and increases productivity and thus profitability (Deming, 1982).

**Quality and Organizational Development**

Throughout the literature, the importance of organizational culture and development is stressed. Gilbert (1987) states that there are two approaches to quality improvement: using technical tools such as control charts and new technology, and using a management strategy which includes increased communication and positive employee attitudes. The latter approach is fundamental to a long lasting quality improvement effort. Quality must be part of the organizational culture. This is more important than technical quality programs that may result from fads and produce short-term improvements. A management survey conducted by Gilbert (1987) found that most executives were confused by the role management plays in quality, and the term "involvement" was perceived differently among managers. The delegation of the responsibility and authority for quality from upper management is not the answer. Rather time, direction, and investment in employee training to lower level employees are required. Quality should become part of organizational development first, and should be communicated throughout the organization. Once the direction of the organization is established, the technical aspect of quality can be used to support the management concept. Only then will the benefits of technical tools and machines be achieved (Gilbert, 1987).

Rao (1985) stresses the importance of management commitment. He states that value strategies emphasizing productivity excellence must be developed. Rao (1985) also recommends that management recognize total quality management philosophies. Total quality management encourages a business-oriented quality control system with emphasis on prevention rather than the traditional inspection-oriented quality control system with emphasis on detection. A move towards modular manufacturing can reduce the amount of inspection in
the production process as the responsibility of quality becomes that of the cross functional team. Team members are compensated for both meeting their production goals and for the quality of the products they produce. Team based manufacturing allows for an increased amount of employee involvement in quality. The organizational culture is an important factor to success. The total quality mission should permeate the company. For this to be possible, communication across all functions must be facilitated. Another critical component is the training of employees in all functions and levels of the organization (Rao, 1985).

In a survey of corporate executives, Ryan (1987) found that executives showed a strong awareness of the importance of quality. However, less than half of the executives recognized the need for a change in corporate culture as part of their endeavor to improve product quality. Thirty percent saw no need to use quality improvement as a strategic activity. The survey found that corporate executives were aware of the importance of product quality, but they were not doing what was needed to achieve it.

Changing corporate culture is not easy. It involves changing the attitudes and beliefs of all employees and executives. Cultural change takes time. This may be the reason why many organizations have failed when implementing quality improvement systems because they have been impatiently awaiting results (Crosby, 1980).

**Statistical Process Control**

There are some measures that companies can take to improve the quality of their product regardless of consumer preferences. One of these measures is increasing uniformity or consistency of the product. Central to the concept of statistical process control is the idea that variation is and always will be present. Thus, any attempt to try to eliminate all variation is unrealistic. The manufacturer of products must specify the amount of variation that is acceptable. This will vary from product to product and should be communicated in the specifications for each product (Aguayo, 1990; Deming, 1982). Reducing variation in
quality characteristics improves quality; an attempt should be made to reduce variation beyond merely meeting specifications. The variation that exists in a process should be quantified so that managers can be better equipped in making decisions and production workers know where to direct their efforts in improving the process. Statistical techniques can be used as tools to improve product quality (Rao, 1985). By collecting data and measuring the amount of variation in a process, managers also can determine the cause of that variation. Variation may be attributable to random causes or a trend due to an outside variable. Knowledge of variation can reduce costs resulting from spending money to reduce variability when, in fact, the variability is due to random causes in the process. Walter Shewhart developed the concept of understanding the sources of variability by differentiating between the causes of variation. He used the terms "assignable cause" and "chance cause," (Shewhart, 1980).

Deming popularized these terms as common causes of variability and special causes of variability (Aguayo, 1990). Common causes are part of the process and are always present. Common cause variability is not necessarily small or acceptable variability. Special causes of variability are not part of the process and are not present all of the time, but exist in special circumstances. A control chart is used to differentiate between common and special causes of variation in quality characteristics. Common cause variability is short term variability and is used to set control limits for the process. A process that has only common cause variability is said to be in statistical control. If a process is in statistical control, managers can make predictions about future performance of the process. If managers wish to reduce the variability of a stable process, they must make fundamental changes in the process. Adjustment of the process will increase the variability. A process which exhibits both common cause variability and special cause variability is unstable. An unstable process does not necessarily have large variability, but the variability is unpredictable. If a process is
unstable, out of control signals, such as points outside of control limits or patterns in the
data, will be visible on the control chart (Nolan & Provost, 1990).

Quality Assurance in Apparel Manufacturing

Quality in the apparel industry focuses on multiple variables and involves establishing
requirements, primarily as standards and specifications, for products according to customer
needs. These requirements include the physical components that make-up the garment, such
as fabric and trims; the dimensions that relate to product and consumer interaction, such as
the relationship between pattern and design with fit and size; and measures of quality, such as
consistency in color or size and performance aspects (Cooklin, 1991; Mehta, 1992; Tyler,
1991). Ideally, quality in apparel production should be built into the product, and continually
addressed throughout the manufacturing process beginning with the design of the garment
and continuing until the garment reaches the retail shop floor (Cooklin, 1991; Mehta, 1992).

Design and Pattern Development

At the design stage quality related factors are considered. Designers should be familiar
with the properties of the fabrics they use, the capabilities of the production process, and the
needs of the consumer (Lowe & Lowcock, 1975). Once a design has been adopted for a
line, it becomes a style (Glock & Kunz, 1995). The preparation of a style for production
involves perfecting fit, developing patterns, selecting materials, and writing specifications.
All of these characteristics affect the quality of the garment. The fit of the garment refers to
how the garment conforms to the body. For certain product categories fit is an important
quality characteristic and may differentiate a company's product from that of its competitors.
Once a company has established the desired fit for its customers, it is important for that
company to achieve consistency in fit so that their customers can depend on the fit of that
particular product from style to style and season to season. Sizing standards refer to
achieving consistency within each size which is another important quality characteristic dependant upon the tolerances set for the specifications. Style specifications include specifications for size and fit, materials, spreading and cutting, garment structure, and finishing (Glock & Kunz, 1995).

Ensuring quality at the postadoption stage may involve making sample styles in pseudo production situations and analyzing samples for fit, drape, and sewability characteristics. The complexity of sample preparation depends on the quality demands of the consumer and the company's quality standards. It is important that the methods used to produce sample garments are representative of those to be used in production, and that the skills of the operator producing sample garments is not higher than those operators who will be producing the actual garment in production (Cooklin, 1991; Glock & Kunz, 1995; Lowe & Lowcock, 1975; Mehta, 1992)

Once the desired fit and style have been achieved, production patterns are developed. Pattern grading is an important part of apparel product quality. Patterns should be correctly graded for size according to the company's standards for fit and size (Glock & Kunz, 1995).

Many aspects, such as an emphasis on accuracy in pattern shape and correct positioning of notches, are included in pattern marking which help build quality into the product. Accuracy in pattern marking can determine quality in terms of size, fit, and design of the finished product. Quality at this stage is particularly important as it serves as a starting point for quality to be built into the garment (Cooklin, 1991; Glock & Kunz, 1995).

Fabric

In 1977 the Apparel Quality Committee of the American Apparel Manufacturers Association (AAMA) tried to assist companies in the purchasing of raw materials (AAMA, 1978). Results of a survey of manufacturing companies indicated that manufacturers were not purchasing goods using specifications and that there was a general lack of communication
between fabric suppliers and manufacturers. AAMA recommended that manufacturers should purchase raw materials using specifications and increase communication between vendor and customer throughout the pipeline. AAMA highlighted the importance of fabric quality in garment manufacture because so much of the cost of producing a garment comes from fabric cost. The quality of fabric affects both the production process and the quality of the final product. The report did not focus entirely on fabrics, and stated that quality requirements for other materials such as thread and trims also should be communicated in a similar manner focusing on specifications and two-way communication.

The quality of materials is important in achieving a consistent product that meets specified requirements. Achieving a consistent level of product quality begins with the consistency of materials. Variability in the materials used at the beginning of the process increases variability in the end product. AAMA stated that in order to achieve a consistent level of quality, specifications should be written for every material purchased. Specifications should be written in a way that they address properties that will cause problems in production and that may result in a defective final product. Information which may be included in fabric specifications includes: fiber content, physical characteristics such as yarn count, performance characteristics that address how the fabric will perform in its end use, acceptable limits for visual defects such as fabric flaws, and shading details which specify the color matching requirements of the materials. Specifications may use standard test methods such as those developed and published by the American Society of Testing and Materials (ASTM) and the American Association of Textile Chemists and Colorists (AATCC) (AAMA, 1978).

Jacobsen (1985) stated that giving the responsibility of inspection to fabric manufacturers is effective only if apparel manufacturers provide suppliers with clearly written specifications which outline the requirements for each fabric purchased. He highlighted the importance of inspection of fabric, stating that failure to do so results in
problems in the cutting room because the spreading operation may have to be stopped several times due to defects in the fabric. A further problem with inspection at the spreading stage may be a conflict of interest between productivity and quality because cutting room employees are often paid according to the volume of fabric spread. Further, with reduced inventories, inspection at the spreading stage could cause major time delays if faulty fabric is rejected and more fabric has to be ordered. Powderly (1988) stated that the responsibility of communicating quality problems in fabric should be that of the fabric manufacturer, but agreed that fabric purchasers should make the quality level of fabric required for their products known to fabric manufacturers.

The Worth Street Rules, a standard set of business practices applicable to the purchase and sale of textiles, were developed in 1941 and most recently updated in 1986 (American Textile Manufacturers Association, 1986). Sections of these rules may be included in sales contracts between mills and manufacturers. The rules include guidelines for buyers and sellers of textile materials, and a section on fabric quality which includes information such as recommended tolerances for fabric length, width, count, and weight. In addition, the rules include a section on fabric grading and offer suggested definitions for what should be considered first and second quality fabric (American Textile Manufacturers Association, 1986; Powderly, 1987a, 1987b).

In a survey of quality control personnel in the apparel industry, Hudson (1982) found that there were commonalities in problems appearing in piece goods. Shading problems caused the worst problems with fabric flaws second. Traditionally, color measurement has been carried out using human inspectors working in controlled lighting conditions. This method is subject to human variability and subjectivity. A move is being made towards instrumental color measurement which reduces the problem of human variability, but may
introduce problems of unrealistic or impractical shading specifications that require shade matching beyond the ability of the human eye (Tyler, 1991).

The Textile and Apparel Linkage Council (TALC) was formed to help U.S. companies become more competitive in the global marketplace. One way of improving competitive advantage was through voluntary standards which provide solutions to problems through co-operation between suppliers and manufacturers. Such voluntary standards include flagging of fabric defects by suppliers, so that manufacturers do not have to inspect each roll of fabric as it comes into the plant. Marking flaws reduces costs and saves time for manufacturers. Also, when suppliers provide shade data on hang tags, the time spent manually shade sorting is reduced. These aspects contribute to quick response which allows domestic manufacturers to compete through shortened lead times (Little, 1988; Mehta, 1992; Tyler, 1991).

Quality in the Cutting Room

The level of quality that can be achieved in cutting, construction, and the final product is dependent upon the standards for spreading. The spread should be tension-free and flat so that the fabric is neither stretched nor wrinkled, and the desired fit of the finished garment is not altered. Since most production uses cutting of multiple plys of fabric, plys should be aligned accurately to assure precise cutting. Also, the fabric should be free from static electricity which can create problems, such as fabric plys clinging together causing inaccurately cut parts.

The cutting process contributes to the quality of the final product. The appropriate cutting equipment should be used to assure that the cut parts are accurate and free from raveling. Accurately cut parts contribute to sewing efficiency and thus the quality of the final garment (Glock & Kunz, 1995).
Inspection

Inspection in apparel manufacturing is defined by Mehta (1992) as "the visual examination or review of raw materials (such as fabric, buttons, zippers, sewing threads, and trims), partially finished components of the garment, and completely finished garments in relation to some standards, specifications, or requirements, as well as measuring the garment to make sure that they meet the required measurements" (p. 8). The intent of inspection is to detect any problems or nonconformities as early as possible in the manufacturing process so they can be corrected and other problems of the same nature can be prevented. The further down the pipeline that defects are discovered, the more costly they are to the company. A defect found at the end of the manufacturing process can be five times more costly than if it is found at the beginning of the process (Jacobsen, 1985; Mehta, 1992). Mehta (1992) presented the inspection loop that must be completed for inspection to be effective. The inspection loop includes inspection, detection of defects, feedback of defects to the appropriate personnel, determination of the causes of defects, and correction of defects and the process that created the defect. The critical part of this inspection model is the determination of the causes of defects and implementing changes to the process. It is this stage that allows for prevention of future defects of the same nature, and thus improves quality.

According to ANSI/ASQC Standard A3 (1987) the term quality audit is defined as "a systematic and independent examination and evaluation to determine whether quality activities and results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives" (p. 6), whereas, the term inspection is defined in the same standard as "activities, such as measuring, examining, testing, gauging one or more characteristics of a product, and comparing these with specified requirements to determine conformity," (ANSI/ASQC, 1987, p. 5).
Inspection can be carried out at three specific stages in apparel production: when materials arrive (raw materials inspection), during production (in-process inspection), and after the product has been completed (final inspection). The discovery of defects at the raw materials inspection stage can reduce greatly the costs of inferior quality products being produced due to poor quality fabric. Un-controlled incoming fabric can cost the company 1 - 2% of their profits (Jacobsen, 1985).

Fabric inspection should compare actual fabric received with company standards. Material inspection may be the responsibility of fabric suppliers. Fabric inspection machines which identify defects and variations in width are commonly used to inspect fabric. Several point grading systems exist that determine fabric quality by assigning point values to defects based most often on the length of the defect. A total number of defect points are calculated for the length of fabric. Fabric quality is related to either the total number of defects for a standard yardage or an average defect point value per yard. The fabric is either accepted or rejected based on an acceptable point value for first quality fabric. The acceptable point value may change according to the product being made (Mehta, 1992; Powderly, 1987a 1987b).

No standards describe a minimum yardage that should be inspected. However, a general rule is that fabric intended for garments which will sell for a retail price of $20 or more will receive 100% inspection. If the price will be less than $20, 10% inspection is conducted. Some manufacturers or suppliers may mark defects using tags to cut around defects when the fabric is being cut (Mehta, 1992; Powderly, 1987a, 1987b).

Materials other than fabric also should be inspected. Sewing threads should be inspected and tested for construction, sewability, imperfections, finish, color, package density, winding, and yardage. Zippers should be checked for dimensions and color uniformity. In addition, zippers and sewing thread should be checked for performance aspects which include washability, colorfastness, and strength. Buttons should be checked to ensure that
they have accurately positioned sew holes large enough for the button to be attached correctly. The color shade of buttons should be matched, and in terms of durability and color they should be fast to garment care. Buckles should be inspected for visual defects. Snap fasteners should be checked to ensure that they are able to be attached properly (Mehta, 1992).

In-process inspection takes place at specific points in production. The purpose is to detect defects before an entire garment has been produced, and maximum value has been added. In-process inspection may be conducted by specialized quality inspectors or by sewing operators either before or after operators perform specific work on a part. Because mistakes are found during production, in-process inspection can reduce costs due to repairs and reduce the number of seconds that reach the consumer (AAMA, 1976). Placement of inspection points in the production process will vary according to the particular product being produced and the process. Generally, inspection will be conducted before a bottleneck operation (an operation that causes difficulties or holds up production flow), or before an operation that is irreversible. If value is added to inferior quality products at these operations, it would be most costly to the company; therefore, inspection points should be strategically placed to assure only first quality garments reach these operations.

Final inspection involves checking complete garments for freedom from defects and adherence to size and fit standards before they leave the manufacturing plant. This inspection may be done before or after packaging and often includes extensive measuring of the garment for size and sometimes checking for fit on a mannequin or live model. At this stage any defects found are the most costly ones to repair. Final inspection should not be completely relied upon in achieving a quality product. Quality cannot be inspected into a product, but rather should be built into the product from the initial design stages onward (Mehta, 1992).
The individual who bears the responsibility for inspection has changed throughout the years. Initially inspection was the job of the craftsman, but at the onset of industrialization, the inspection responsibility moved to specialized inspectors. Although this method is still popular today, a move is being made towards abolishing the role of the production inspector and returning the responsibility back to the production operator. By increasing the responsibility of the production operator, more pride in workmanship should result, and the quality of the finished product should improve. The production worker is empowered to make decisions as to whether a product conforms to specification; however, the decision on whether the product is fit for its end use still must be made by specialized quality personnel because specifications do not always reflect fitness for use criteria (Sears, 1983).

Sampling Procedures For Inspection

The decision of how many products to inspect can vary considerably. If the entire production lot is inspected, it is referred to as 100% inspection. A decision is made to accept or reject each individual unit. Depending on the method of garment evaluation, this method of inspection could provide the greatest amount of information about the entire production lot, but it may be costly to the company and, because of the human element involved, does not guarantee the detection of all defects (Mehta, 1992).

The expense of inspecting every unit can be reduced by taking a sample of the production lot. A sample is defined as "one or more units of product drawn from a lot or batch, units of the sample being selected at random without regard to their quality. The number of units of product in the sample is the sample size" (Department of Defense, 1989 p.4). Statistical sampling deals with the number of items in a production lot that should be inspected to make a valid judgment about the quality of that entire lot. The objective of taking a sample is to accurately find out about the quality of the entire production lot from a sample of selected products.
Statistical sampling is the best alternative to 100% inspection and sometimes may provide more information than 100% inspection if the units sampled are tested for performance (Mehta, 1992). Statistical sampling or acceptance sampling results when a random sample of units is inspected, and a decision is made on whether to accept or reject the lot based on the results of inspection of that sample. When selecting a random sample, each unit has an equal chance of being selected. Acceptance sampling decreases the chance that small lots are over inspected and large lots are under inspected, and therefore reduces the risk of making the wrong decision on the lot. With acceptance sampling, these risks are quantified. The number of items inspected can vary and may be calculated based on a predetermined sampling plan. The decision on the sample size is made depending on the number of production units in the lot (frame) and the average percentage defective that can willingly be accepted. The acceptable quality level (AQL) is the maximum percent of defective products that can be considered satisfactory. As the desired acceptable quality level (AQL) becomes less, the sample size must increase to ensure that minimum level of defective products (Mehta, 1992).

The military standard 105 (Mil-STD-105) is a sampling scheme which provides tables for selecting sample size based on production lot size and accepted quality level. There are 3 groups of sampling plans: single, double, and multiple plans. The Mil-STD-105 has been in effect since the 1950s and is the most widely used acceptance sampling scheme in the world. The military standard is used widely in the apparel industry. Acceptance sampling can be used to make statistical inferences on a particular lot, but cannot be extended to include any other lots. An inference cannot be made about the production process that produced the products using acceptance sampling. In order to make inferences on the production process, data must be collected over time, and other methods of statistical process control, such as the
use of control charts, must be used (Department of Defense, 1989; Mehta, 1992; Pond,
1994).

An alternative to 100% inspection and statistical sampling is spot checking. Under this
system, random shipments are inspected, and some production lots are shipped without
having been inspected. The disadvantage of this procedure is that no information is gathered
to determine the quality level of these shipments that have not been inspected. This method
of inspection is not considered to be a good alternative to 100% inspection because the
information gathered for the lots inspected cannot be extrapolated beyond these lots;
therefore, the lots which have not been inspected may contain an unacceptable level of
defective products (Mehta, 1992).

Another alternative is known as arbitrary sampling. A specific percentage of each
production lot is inspected regardless of the size of the production lot. A common percentage
is 10%, and production lots would be accepted or rejected based on inspection of 10% of the
lot. The disadvantage of this method is that 10% is not always an adequate size to be
inspected in each lot. Some lots may require more or less inspection, depending on their
characteristics. This method does not address the possibility that production lots differ in
characteristics and the accepted quality level may differ from lot to lot (Mehta, 1992).

Materials Testing

Materials testing refers to the testing of fabric and other garment components at various
stages in the manufacture of products. The testing of materials usually is conducted in a
laboratory setting and is designed to evaluate various end-use characteristics of the product,
such as durability and appearance retention. Materials testing or textile testing is an important
part of any quality assurance program, because it can identify problems that may otherwise
go undetected until reaching the consumer. Some defects are not visible, but become
apparent during manufacture or wear of the garment. Such defects are known as latent
defects and, unlike patent defects, cannot be detected during visual inspection of fabric or garments, but require performance testing. An example of a latent defect that cannot be detected without testing is shrinkage. These defects are potentially costly to a manufacturing company that does not carry out any performance testing, because the defects will be detected only when maximum value has been added to the product and when it is in the consumers hands causing dissatisfaction and ill will (Powderly, 1987a).

Usually, fabrics or products are tested and the results are compared with performance specifications for the product. Specifications are written as minimum requirements with tolerances for a product or fabric, and usually include a standard test method for testing each characteristic. Textile testing is carried out to ensure that products or fabrics meet specifications. Minimum recommended fabric performance specifications for selected properties and end-uses have been developed by the American Society for Testing and Materials (ASTM) committee D-13.56 on performance characteristics for textile fabrics. These performance specifications also cite the test procedures to be used to test these items (ASTM, 1993).

There are several organizations that develop and publish standard test procedures for textile and apparel performance characteristics. These organizations include ASTM, American Association of Textile Chemists and Colorists (ATCC), Federal Standards textile test methods, American National Standards Institute (ANSI), and International Organization for Standardization (ISO). The impetus to develop a standard test method or performance specification usually arises from a quality or performance problem with a certain type of product and thus a need to develop a method of evaluating a specific quality characteristic. A committee of experts is formed by the standard-setting organization; these experts use their knowledge and expertise to develop the standard test method. The committee will agree upon the test method only when every member is in agreement with all parts of the test method.
The test procedures written by these organizations usually include the scope of the test and a basis for evaluating the results of the test. There are several books of standards available to manufacturers and retailers who can choose which test methods and specifications are applicable to them. Some manufacturing and retailing companies have developed their own standard test methods for specific garment categories which are often based on the companies past experience with a specific product category. Most standard test methods are voluntary and include no means of accepting or rejecting the results (AATCC, 1993; Kadolph, 1991; Mehta, 1992; Merkel, 1991; Solinger, 1980).

Most discussion on performance testing in the literature relates to fabrics or garment components. Product testing results when constructed garments or portions of constructed garments are tested, which allows for information regarding performance of components as they interact in the garment and compatibility of individual components to be gathered. Performance testing provides a realistic interpretation of how the product variables will interact in the hands of the consumer.

The Organization of the Quality Function

The term quality when used in an organizational context can have different meanings. Quality control is the traditional term given to the task of ensuring that materials and products meet a set of specified requirements. Quality control involves the testing and inspection of materials and products, and usually takes place as the products are being produced. Quality assurance relates more to the entire company and usually evolves from a company's adoption of a total quality management philosophy. Quality assurance includes more than materials and products and includes the conformance to standards throughout the company (Werner International Inc., 1990).

Discussion in the literature of quality within organizations can be divided into two opinions. Some sources state that quality should be a separate function within a company
which is responsible for the assurance, management, and control of quality. Other sources describe quality as being integrated throughout the organization.

Under the philosophy that quality is a separate function, many authors believe that quality personnel should report to the quality director/manager and not to production managers (Cooklin, 1991). The organization of the quality function is described by Kohlbeck (1984) who believes that quality should be a separate function in the organization. Kolbeck's model of the quality function (Figure 1) outlines the functions of the quality assurance department as being important to product development, manufacturing, customer support, and administration. Quality specialists work with product designers to ensure the prevention of defects at the earliest stages in the manufacturing process. Quality personnel also provide their expertise at the manufacturing level where they organize the inspection and testing of materials and products. Under Kolbeck's model of quality assurance, the quality director provides expert advice to top management and is responsible for auditing the performance of the quality function. Kohlbeck stresses the importance of the quality function being independent from manufacturing, and states that, as a separate function, the quality assurance department has responsibility for these areas and for ensuring that the desired quality level is maintained throughout these functions. This explanation of quality within the organization focuses on a separate quality function and personnel who are involved in various aspects of the organization. A problem with this type of quality organization is that quality can be viewed as the responsibility of the quality personnel and not every employee in the company (Kolbeck, 1984; Glock & Kunz, 1995).

Another opinion on the organization of the quality function within the organization is that the philosophy of quality should permeate throughout the company and become the responsibility of all employees. Written documentation of the company's quality philosophy and the required procedures to achieve quality goals will help communicate the policies
established by management of the organization. Under this philosophy, the quality assurance manual should be shared with all employees of the company because, if quality is their responsibility, they must be educated on the quality policies of the company so that they can effectively do their job. Under this philosophy, there are personnel who are responsible for quality; however they may be an independent management group or a group of representatives from each division in the company. These individuals do not form a separate division of the company (Glock & Kunz, 1990).

The previously mentioned "taxonomy of the apparel merchandising system (TAMS)" presented by Glock & Kunz (1995) shows the functions of merchandising and how they relate to other functions in the company. This model illustrates the areas where quality is addressed within the entire manufacturing system from preadoption product development to production, and can be used to illustrate the integrative nature of quality within the organization. Within that taxonomy, quality is addressed in preadoption product development, postadoption product development, business planning, and sourcing strategies for materials and production. The underlying assumption of Kunz's taxonomy is that quality permeates throughout the company and that quality is not a separate function.

No matter what philosophy for quality within the organization is adopted the ultimate responsibility for quality must fall upon top management, and therefore they should be committed to producing a quality product.

Current Quality Assurance Practices in the Apparel Industry

An exploratory study of apparel manufacturing firms was conducted by Karnes and Kanet (1994). The purpose of their study was to find out about quality philosophies and practices. The results of the study indicated that there is a need to improve existing quality practices in the apparel industry. There appears to be a lack of employee involvement in quality activities and minimal use of quality training programs. A lack of communication
with suppliers is also evident. Less than half the companies surveyed give written specifications to their suppliers. Many companies receive specifications verbally from their customers. Companies surveyed rely heavily on final inspection as their only means of assuring quality. Only half of the companies surveyed stated that they assure quality throughout the manufacturing process. The authors suggest that the apparel industry needs to focus more on improving production processes rather than trying to use inspection as a means of improving quality. A lack of quality measurement systems also existed with the surveyed companies, and the authors suggest that companies should have a measurement system that quantifies the cost of poor quality to the company.

The previous review of quality practices in apparel manufacturing has highlighted some important areas in quality. The quality of fabric and materials is of vital importance. If companies intend to produce consistent products at a desired level of quality, they must begin with the quality of components (Cooklin, 1991). If quality is to be built into a product, the "building blocks" of the product also must adhere to quality standards (Boznak, 1994). Companies must set standards for materials and communicate these standards to suppliers using clearly written specifications (AAMA, 1978). The second important area is that of inspection. Inspection has a role to play in the production of apparel; however, it should not be used as the only means of achieving quality, and should be used throughout the production process. If decisions are to be made on an entire production lot based on inspection, an appropriate method of sampling should be used (Mehta, 1992). Inspection of products cannot say anything about the process that created these products, or any products that will be produced by that process in the future (Department of Defence 1989). When building quality into a product, the process that creates the product must also be considered (Pond, 1994). A final area of importance to the quality of products is that of employee
involvement in quality. Quality should be infused throughout the company and should be the responsibility of every employee (Glock & Kunz, 1995).

**Educational Text Books**

In this section, I review educational text books that include information on textile testing and textile quality assurance. The texts reviewed include those that focus primarily on textile quality assurance or textile testing, those that focus on apparel manufacturing, and those which are primarily directed towards textile science, but also include sections on textile testing and quality assurance.

**Texts that Focus on Textile Testing or Quality Assurance**

Three text books that focus on textile testing or quality assurance were identified. These are: *An Introduction to Quality control for the Apparel Industry* by Pradip V. Mehta (1992), *Textile Product Serviceability* by Robert S. Merkel (1991), and *Principles of Textile Testing* by J. E. Booth (1969).

Mehta (1992) addresses the quality management, apparel construction, and physical testing aspects of quality in the apparel industry. The author's objective was to discuss the areas of fabric quality characteristics and apparel quality characteristics in one text. The book is intended to be representative of how quality should be addressed in the apparel industry - as a management philosophy rather than a technical procedure. Overall, Mehta views textile product quality in the industrial context as a business strategy. He integrates management philosophies, technical procedures, and garment construction aspects of quality into one text which aims to discuss quality control in the apparel industry in an integrative manner.

Throughout the book there is an industrial orientation and textile quality procedures are discussed in context. The text briefly addresses the concept of quality and why it is of such importance. Inspection in reference to quality control in the apparel industry is addressed in
great detail, and the author provides a model of inspection which identifies how inspection must be carried out in order to be effective. The chapter on inspection is discussed in three sections: raw material inspection, in-process inspection, and final inspection. Inspection equipment, classification of defects, point systems, and sampling are all addressed in some detail. Diagrams have been included in this chapter which help to describe the measuring of garments, common garment defects, and garment defects which are not readily apparent.

Textile testing and product evaluation are discussed together in one chapter. Real life scenarios are used to highlight the relationship between textile testing and product quality. ASTM and AATCC standard test methods are described along with some of the equipment used to carry out testing. Other chapters in the book are: care-labeling of apparel and textiles, shade sorting, flammability, objective evaluation of fabric hand, quality costs, customer returns, impact of advanced apparel manufacturing technology on quality control, product liability, textile and apparel linkage council, and how to start a quality control program.

The objective of Merkel (1991) was to describe methods of evaluating fabrics for use in apparel and home furnishing products. The orientation of this book is towards material testing and the technical aspects of evaluating quality characteristics for materials used in producing textile products. The text book is divided into two parts. Part one addresses the fundamental concepts of fabric quality such as fabric specifications, getting reliable test results, and includes a chapter on what quality is and what the results of poor quality are. This chapter also includes the goals of laboratory testing. Part two of the text book discusses the various tests conducted on textiles. Each chapter addresses a performance characteristic, such as fabric strength and elongation, abrasion and wear, and colorfastness tests. Within each of these chapters, the terminology, standard test method, equipment, and fabric parameters affecting the characteristics are addressed. Within Merkel's text book very little
discussion on products is apparent, and construction aspects of apparel quality are not addressed.

The objective of the text by Booth (1969) is to describe the physical and mechanical aspects of textile materials. The text is technical in nature and does not address product or product construction aspects of quality. Textile testing as a form of fabric evaluation is addressed in great detail. Methods of selecting samples for material testing and types of statistical analysis are also addressed in some detail. Fiber, yarn, and fabric dimensions of quality are addressed, and test methods and equipment used to test these characteristics are also discussed.

**Texts That focus on Apparel Manufacturing**

One apparel manufacturing text book was identified that includes aspects of quality assurance which may be applicable to students in quality assurance/ textile testing courses. That text is *Apparel Manufacturing: Sewn Products Analysis* by Ruth Glock and Grace Kunz (1990, 1995). The quality aspects of this text will be addressed in the following discussion.

The objective of the text by Glock and Kunz (1990, 1995) is to describe significant components related to garment manufacturing. The text is divided into five parts. Quality is specifically addressed in parts 1, 2, and 3, but is continually addressed throughout the text when various aspects of apparel production are discussed. For example, when pre-assembly operations are discussed, quality is addressed at each stage: marker quality, spreading quality, and cutting quality. The effect each of these operations have on quality and factors of that operation which determine quality are discussed. In part 1 of the text book, concepts of performance and quality are discussed, and the relationship between apparel quality and product performance is discussed. Quality within the organization is introduced along with the concept of total quality management. In part 2, garment analysis is discussed which addresses methods of analyzing garment quality. Garment analysis in the industrial setting is
discussed. Part 2 includes sections on product standards and specifications, sizing, and material selection. In part 3 of the textbook materials management is discussed, which includes a chapter on fabric quality and performance which addresses fabric quality from several dimensions. Overall, aspects of garment quality and how it can be achieved are integrated throughout this textbook. The emphasis is on apparel quality during production.

Textile Text Books Which Include Textile Testing or Quality Assurance

Several basic textile textbooks include dimensions of apparel quality. A review of texts used for introductory textiles courses found that many of these books include a chapter on fabric performance testing. In most cases these provide the student with a brief overview of fabric performance testing and standard testing organizations such as the American Society for Testing and Materials (ASTM) and the American Association of Textile Chemists and Colorists (AATCC).

Joseph (1988) provides students with an overview of fabric testing and briefly describes the role of the standard test method and the standard testing organizations ASTM and AATCC. Performance standards are also briefly discussed. The text includes information on specifications and how they are used. Some fabric performance characteristics, such as abrasion resistance, dimensional stability, and evaluation of colorfastness to various insults are described along with a description of various pieces of testing equipment.

Hudson, Clapp, and Kness (1993) devote one chapter to the evaluation of textile properties. The chapter provides a brief introduction to standards organizations, standard test methods, and the use of specifications. Specific performance characteristics and test equipment are not addressed.

Smith and Block (1982) provide a brief summary of standards and textile testing. The chapter includes a discussion on performance standards, care labeling, standard test methods,
and standards organizations. Again, this text does not describe specific test methods or characteristics, but does include a sample ASTM test method.

Tortora (1992) provides a relatively detailed overview of textile testing and standards. The chapter includes discussion on standards organizations and test methods, and an overview of textile testing which includes discussion of specific fabric characteristics and physical performance characteristics. These include: fabric count, weight, thickness, tensile strength and elongation, dimensional stability, abrasion resistance, resistance to pilling, colorfastness, and flammability. Each performance characteristic is briefly described giving the student an explanation of how the performance characteristic is evaluated. Examples of equipment that may be used also are given.

Price and Cohen (1994) provide a chapter which gives a relatively detailed discussion of fabric performance testing. The objectives of the chapter are to provide students with an understanding of why textile testing is conducted, the terminology used in textile testing, and the methods and equipment used for the testing of textiles. The chapter includes discussion on textile standards organizations and standard test methods. Methods of testing physical performance characteristics and the equipment used are discussed in detail.

The most comprehensive information is provided by Cohen (1982) in the text Beyond basic textiles. Cohen includes four chapters which include textile testing and textile quality assurance information. An introductory chapter outlines the purpose of textile testing and its uses. A further chapter outlines the various types of standard test methods and provides a detailed review of physical performance testing for various characteristics. A chapter on color introduces students to color terminology and aspects of color as they refer to the apparel industry. The text has an industry orientation and provides a detailed discussion of textile testing.
Although the extent of the information provided by these texts varied, they were all similar in content. All of these textile text books address materials testing and aim to introduce the student to the technical aspects of fabric performance testing.

Conclusion

Most texts used in textile quality assurance/textile testing classes are of a technical nature and focus on materials testing. Standards organizations and standard test methods, and fabric physical testing are the primary focuses of these books. They seldom address performance testing in terms of a complete product or end-use. Only two text books, those by Mehta (1992) and Glock & Kunz (1990, 1995), provide an industrial perspective on the quality of apparel items. In both of these books, quality in terms of entire products is addressed. Mehta combines the technical aspects of physical testing with the construction aspects of apparel production. Both Mehta (1992) and Glock & Kunz (1990, 1995) address the organization of quality assurance within apparel organizations, and both approach the subject of apparel quality from a business strategy perspective.

The Relationship Between Education and Industry

In this section I address educational issues concerning the relationship between education and industry. Again, this is a brief overview of the literature available on this subject; it is intended to highlight the subject as it pertains to this study.

The application of total quality management philosophy principles to the educational setting has been addressed by several authors (Bonstingl, 1994; Helms & Key, 1994; Hubbard, 1994; ). However, there is some debate over the role played by students: should students be considered consumers or employees in the classroom? The major differences between business and education make the total quality management philosophy difficult to implement in education. Using the marketing concept, some authors refer to students as the
product of education and employers as the consumer. Clark (1990) stated that during this climate of increasing global competition, an educational system which prepares students and provides the skills necessary for industry is increasingly important. He suggests that employers are the customers in the relationship between education and industry. The author expressed concern over education's ability to meet the needs of employers in industry. He stated that efforts should be returned to the development of partnerships between business and education, whereby each partner shares information and communicates requirements (Clark, 1990).

Cowles and Franzak (1991) take a marketing approach to addressing the issue. They state that, in order to meet the needs of the market (employees), educators must conduct some form of market research beginning with identifying the needs of the target consumer. Educators must remain aware of the needs of employees in industry, i.e., the demands of the market, so that they can develop their product (students) to meet these demands, i.e., have appropriate skills.

Similar studies have been conducted in the area of textiles and clothing which identify employment needs for students in the areas of retail buying and fashion marketing (Garner & Buckley, 1988; Kotsiopulos, Oliver, & Shim, 1993). Kotsiopulos, Oliver, and Shim (1993) compared perceived buying competencies between retail buyers, retail managers, and merchandising students. They found that there were significant perceived differences between each group in their perception of the job of retail buyer. The emphasis put on merchandising programs was not found to match the perceptions of what skills retail buyers thought were important for the job. This study provided recommendations for the competencies necessary for graduates in retail buying. Garner and Buckley (1988) explored the curriculum content needed for success in fashion marketing careers. They surveyed educators, graduates, and employers to determine if there was consensus among the three on
the relative importance of content areas in the textiles and clothing curriculum. They found significant differences in several areas of course content and suggested that educators examine these areas when making recommendations for course content.

These studies have highlighted that there is a need to study industry practices in order to determine if course content is such that it will adequately prepare students for jobs in industry. No studies comparing textile quality assurance course content with industry practices were found.

Summary of Literature Review

The review of literature on quality assurance practices highlighted ideals related to practices that achieve quality in apparel products. Much of the literature written on the subject of quality assurance in apparel manufacturing is theoretical in that it proposes what practices should be carried out in order to achieve a quality product. There is little literature on the subject of quality assurance in the apparel industry that provides a practical perspective on what practices are actually carried out. Only one article was identified (Karnes & Kanet, 1994) that provided an assessment of current quality assurance practices in industry.

The idea that quality should be addressed from the beginning of the apparel production process, i.e., product development, and should be addressed continually throughout the process was recurring throughout the literature. There are aspects of quality to be addressed at every stage in the process (Glock & Kunz, 1990). The quality of raw materials is of major importance to the quality of the final product. Efforts have been made by AAMA to highlight this point to apparel manufacturers. According to the literature, written specifications, as a method of communicating quality requirements to suppliers, are of critical importance in assuring the quality of raw materials. Inspection as a method of achieving quality during production was discussed in the literature. In order for inspection to be effective, it must be
carried out with the correct objectives in mind: highlighting defects and correcting the process that produced the defect with a view to preventing future defects of the same nature. If this method is not followed, inspection is not an effective method of ensuring quality during production (Mehta, 1992). Most of the literature on materials testing refers to the testing of materials or fabric. There was little literature which addressed the testing of other materials or when materials are combined into products.

Themes which were recurring throughout the literature on management philosophies were management commitment to quality (Crosby, 1980; Glock & Kunz, 1990; Rao, 1985), corporate culture (Crosby, 1980; Ryan, 1988), and the importance of process improvement (Aguayo, 1990).

A review of educational texts highlighted that a predominantly technical approach is taken by texts that focus on textile testing (Booth, 1969; Merkel, 1991). Other texts which focus on apparel manufacturing provide students with an overview of how quality should be addressed throughout the process. Only one text book integrated the technical aspects of performance testing, garment construction aspects of quality, and business quality strategies (Mehta, 1992).

Finally, a brief overview of educational issues concerning the relationship between education and industry suggests, that in order to develop courses that will adequately prepare students for industry jobs, there is a need to study industry practices.
METHOD

In this chapter the technique, sampling procedure, data collection, and method of data analysis are described. Since different methods were used for the two parts of the study, the chapter has been split into two parts: industry study and course content study.

Industry Study

Technique

In the industry study I explored quality assurance practices within selected companies. I wanted to collect detailed information regarding how the firm defined itself in terms of quality, how quality was measured, at what stages in manufacturing quality measures were addressed, how the quality function was organized, and how quality was integrated within the company. Since quality practices in the apparel industry are not well documented in the literature, the organizational boundaries between quality and the organizational setting are not clear. For this reason I found naturalistic methods to be most suitable to provide in-depth information about quality practices from multiple sources, to analyze quality documentation, and to observe production practices which would provide invaluable information about quality assurance practices within the firm.

Case studies are effective at addressing questions of the how and why within a real-life context. There are six sources of information that can be used in case study research: documentation, archival records, interviews, direct observations, participant-observation, and physical artifacts (Yin, 1989). Interviews are an important method of collecting data in naturalistic research because they allow for collection of information that cannot be observed, and a more in-depth response from the interviewee, which may include events that occurred at a previous time or their opinions and perspectives (Fraenkel & Wallen, 1993; Yin, 1989). In this study I used interviews, direct observations, and documentation.
Sample

The sample of four apparel manufacturing companies was selected purposively. The companies were selected based on four criteria: product category, size, reputation for quality, and geographic location. The companies represent a wide range of product categories. I took this approach because descriptive information about quality practices in general was desired, and not a comparison of quality levels between companies. I thought that firms would be more responsive to participation in a study that did not include their competitors, but rather that they were chosen to represent a product category. I selected medium to large sized companies since I thought that these companies would have established quality programs. The desired size was defined as being more that 100 employees in each manufacturing plant. The companies that were chosen are "leaders" in their field, and are known for producing a quality product. Because the purpose of the case studies was to document the practices employed by companies to reach a level of quality, I thought that these companies would best provide that information. Geographic location was limited to the Midwest because of financial and time constraints.

Within each company sampling for interviews was purposive. Personnel who work directly with quality were selected for interview. In addition, production supervisors, plant managers, and personnel involved in pre-production operations such as purchasing materials, product development, spreading and cutting also were selected where possible. The sampling had a snowballing affect. When I addressed certain concepts or practices, often interviewees would suggest a more appropriate respondent to provide the information. I would locate that person, and in all cases was able to interview the appropriate person. In most of the companies there was a key informant who was an invaluable source of information. The key informant was either an employee who had worked with the company for several years and was very familiar with all functions of manufacturing, or was an
individual who showed a great interest in the study. These individuals provided additional informants and shared appropriate documentation with me.

A total of 15 interviews were audio taped and used in data analysis. Two interviews were not audio taped, but the interview notes were used in data analysis.

Data Collection Instruments

A case study protocol (Appendix A) was developed for use in each case study. The protocol consisted of: a statement briefly outlining the purpose of the study, a list of important research questions for the study, an outline of the possible sources where the answers to these research questions may be found, a list of reminders to the researcher, a modified consent form which outlines what information would be provided to the interviewees, a letter introducing the research project, and the interview instruments.

The data collection instruments for the industry study were based on the objectives of the study and consisted of two parts. The first part addressed demographic information about the firm which asked questions such as number and location of plants, company's gross income, goods produced, and the distribution of these goods. This information was usually provided by the first contact in the company during an informal discussion about the company. The second part of the data collection instrument was in the form of a semi-structured interview schedule which addressed the research questions.

The instrument was divided into five parts: job, company quality mission, fabric and raw materials, products and production, and product development and engineering. Part 1 dealt with the interviewee's job and was designed to address educational and industrial background, training, and the skills that are necessary for the job. This section was useful as an informal introduction to the interview allowing the interviewees to talk about themselves. Part 2 the company quality mission, was designed to address the company's commitment to quality and how the company defines itself in terms of quality. This section also dealt with
organization of the quality function within the company and the responsibilities of that function. Part 3, the fabric and raw materials section, dealt with the purchase and testing of fabric and raw materials. Part 4, products and production, dealt with product specifications, testing of finished products, and inspection procedures. Finally, part 5, the product development and engineering section, dealt with the integration of the quality function with product development and engineering.

The credibility of the instrument was established by an expert in textiles and clothing and two industry experts. The instrument was tested during the pilot study which was the first case study. Minor changes were required. It was found that some respondents could answer portions of the interview schedule and that further respondents were suggested by the interviewees to complete sections of the interview. The instrument served only as a guide, and the researcher found that in some instances respondents were more comfortable leading a discussion about quality practices within their company. In these instances the interview instrument was not used, but the researcher did ask several questions during the discussion so that the desired topics were covered.

Data Collection

A letter inviting participation in the study was sent to a contact person in each company (Appendix B). The purpose of the study, methods sought, anticipated length of the study, and some details on what participation would involve were outlined. The letter indicated that a phone call would be made by the researcher one week later. During the telephone conversation the researcher asked for participation in the study and in all cases the companies agreed to participate. Dates and duration of the visits were decided upon and the companies were sent a letter of consent (Appendix C ) to sign and complete. The project was approved by Iowa State University committee on the use of human subjects in research.
On arrival at each company the researcher met with the contact person, who was either the person in charge of the quality function or the plant manager. Details about the study were discussed and demographic information about the company was gathered using the demographic instrument. Usually the study began with a tour of the facilities which helped the researcher gain information about the operations of the plant and to see where a return visit may be made for more detailed observations. In all cases the respondents were very willing to share information about their operations and showed a keen interest in the study. In two of the studies the plant manager or quality director had pre-arranged a schedule of interviews for the researcher. The other two companies allowed the researcher to select interviewees. In all cases the sampling was successful and the researcher was able to interview all relevant personnel.

Individual interviews ranged from 45 minutes to 1 1/2 hours. An audio tape recorder was used to record the majority of interviews. The researcher asked each interviewee if the interview could be tape recorded, and in most cases they approved. At the beginning of each interview the researcher outlined the purpose of the study and spent 1 - 2 minutes informally talking with the interviewees. This created a more relaxed atmosphere and helped to build rapport with the interviewee. Some of the interviews led to informal discussions about quality practices within the firm and the interviewee's personal quality philosophies. Conferences between management and supervisors, and product developers and retailers also were observed.

The researcher spent between one day (10 hours) to one and a half days (15 hours) at each company. The same case study protocol was used for each company and some redundancy of information was achieved between the four companies at the completion of the studies.
Data Analysis

The grounded theory approach proposed by Strauss & Corbin (1990) was used to analyze the data. Grounded theory is an inductive approach, whereby data is systematically analyzed and compared allowing a theory to emerge. First I transcribed all of the interviews onto a word processing package. While doing this, I was able to re-familiarize myself with the data, and during this process some commonalities and differences in the data were highlighted. Each interview was given a code which consisted of the case study number and the interview number. Key quotations are listed in the results to illustrate concepts. Citations refer to the company and respondent. I then read all interview transcripts twice. This practice was recommended by Taylor & Bogdan (1984), who stated that the researcher should have a thorough knowledge of the data before embarking on data analysis. During this process some of the main concepts embedded within the data became apparent. Then a random sample of five transcripts was selected for coding. The transcripts were unitized into meaningful segments of data. This process involves highlighting meaningful portions of the data using brackets. While unitizing these transcripts notes were placed in the margin of the page which were the first stages of coding. From the notes made, a preliminary coding guide was constructed. As codes were added to the coding guide they were constantly compared to existing codes and categories of codes were formed. The preliminary coding guide along with the sample of transcripts were given to another researcher who also applied the codes to the data. After discussion and some condensing of codes, the coding guide was applied to the remainder of the data. The data was analyzed for relationships between codes throughout the data analysis process. As coding progressed, comparison of themes allowed for the codes to be condensed even further.

Throughout the coding process, relationships between themes were explored. After completion of coding all codes were grouped into 16 emergent themes. These themes were
further analyzed and compared. Using the grounded theory approach, theories emerge from relationships between the concepts identified in the data. The researcher spent some time at this stage analyzing the emergent themes and identifying relationships. The major themes which were identified from the data were divided into three categories and from these categories a grounded theory emerged. A grounded theory of factors that affect apparel product quality within the four manufacturing firms studied will be described in the next chapter.

Course Content Study

Data Collection

The purpose of the course content study was to study the content of quality assurance classes in academia. In order to do that, a letter was sent to faculty who teach such courses requesting that they send a current or recent syllabus, course objectives, description of assignments, and course catalog descriptions. In addition, the faculty were asked to provide syllabi and additional information for other courses in which quality was addressed across the curriculum.

Sample

The sample of 41 faculty who teach a quality assurance related course was selected purposively. Institutions were selected based on information found in a search of university catalogues, the reputation of the university, and knowledge of their program. The names of faculty members were selected from the International Textile and Apparel Association membership directory 1994 (ITAA, 1994). The ITAA membership directory lists academic institutions by state, and includes names of the faculty members who are ITAA members and their research interests. The researcher attempted to gain a wide representation of states and included all major state land grant institutions.
Procedure

A letter outlining the purposes of the study and requesting information was sent to faculty members (Appendix D). The letter included a postage paid return envelope for the convenience of the respondents. Three weeks after the letters were sent a second letter was sent to those faculty members from whom a reply had not been received. After the second letter was sent a total of twenty-five responses were received which represents a 61% response rate.

Data Analysis

The course syllabi were analyzed using a qualitative content analysis approach. The objective was to describe the content of quality assurance classes; therefore, a grounded theory or analytic induction approach was not taken. I began analysis by purposively selecting 5 course syllabi to code. These syllabi were purposively chosen because they contained a wide range of topics and provided relatively in-depth information about the course described. The 5 syllabi were coded and a coding guide was developed based on the topics covered in these courses. The coding guide and method of analysis was discussed with another researcher, and after some minor changes the coding guide was used to code the remaining syllabi. Any additional topics were added to the coding guide as they were revealed in the syllabi. The complete coding guide was used as a checklist to tally the number of courses that addressed the topics. Frequencies were calculated which described the number of course syllabi that included each of the topics on the checklist.
RESULTS

The results are divided into two sections. In the first section I discuss results of the industry case studies which are based upon emergent themes from the data. This section focuses on objectives 1 and 2. In the second section I address the results from the course content study which focuses on objective 3. A chapter summary will compare the results from both parts of the study which addresses objectives 4 and 5.

Industry Study

In the following discussion I provide a descriptive discussion of the quality assurance practices in the four companies studied. The discussion revolves around the sixteen emergent themes identified from the data. The emergent themes were grouped into three categories: company characteristics, process stages addressing quality components, and business practices:

COMPANY CHARACTERISTICS
- Size
- Length of time in business
- Organization of quality
- Quality documentation
- Production system

PROCESS STAGES ADDRESSING QUALITY COMPONENTS
- Product development
- Fabric specifications
- Cutting and spreading
- Production
- Engineering Specifications
- Material/product testing

BUSINESS PRACTICES
- Relationship with vendors
- Management philosophy
- Training
- Organizational climate
- Process improvement
Characteristics of the Companies

The first company (company A) was a producer of children's apparel with three domestic production plants and one off-shore operation. The product line was children's sleep wear and sportswear that was distributed nationally for sale through major retail outlets. This company was the first case study and served as the pilot study for the case study protocol.

The second company (company B) was a producer of adult apparel with five domestic plants. The product line was promotional apparel such as casual jackets with company logos. This included licensed sporting goods such as caps and jackets with sports team logos. The products were distributed nationally to a wide range of companies.

The third company (company C) was a producer of casual apparel with 15 domestic production plants and two off-shore operations. The product line was men's, women's, and children's casual denim apparel including jeans, slacks, skirts, shirts, and jackets. The products were distributed nationally and internationally.

The fourth and final company (company D) was a producer of women's better wear apparel. The company was the only vertically integrated company in the study, and had five domestic production plants. The product line was women's skirts, jackets, and suits, which were distributed nationally.

Size and Length of Time in Business

The companies varied in size. Size was determined by the number of production plants, an approximation of the number of employees, and limited information on gross profit for two of the companies. Based on that information, the companies in order of size from the largest to the smallest were: company C, B, D, A. During interviews with company C employees, references were made suggesting that the size of that company was advantageous in achieving a quality product. In particular, when discussing the relationship between
vendors and fabric quality, managers from company C stated that, due to their size, they have a certain amount of power over vendors. In some cases, the company purchased over 50% of the goods produced by a particular vendor; therefore, company C was in a position where they could demand a certain level of quality. Vendors had a financial interest in the quality of goods produced by this company, and thus they maximized their efforts in producing quality fabric. The result has been a successful partnership between the vendor and manufacturer. In contrast, company A, the smallest of the companies studied, did not have partnerships with their suppliers, and references were made continually concerning the quality of fabric. Efforts to establish partnerships have been minimal in this company.

All of the companies have been in business for at least 30 years. Each company was well established and held a good reputation for their product category. Throughout the study, references were made which suggested a relationship exists between the length of time a company has been in business and quality. In some companies, a long history with a certain product category was often mentioned as being a factor in the quality of that company's products. These comments may suggest that these companies have been in business for a long time because of consistent quality. However, this does not suggest that new companies cannot produce good quality goods. One respondent, however, stated that being in business for a long period of time was not necessarily good, because it resulted in resistance to change.

**Organization of Quality**

The organization of quality within each company also differed. Company B and Company C both had quality assurance departments. Both of these quality functions were under the manufacturing function and thus the quality personnel would report to manufacturing.
The quality personnel in Company C were closely involved with product development personnel and were involved in solving quality related problems in production. The philosophy of this company was that quality efforts should be concentrated at the beginning of the process, and they believed that by having quality personnel involved at the developmental stage, the quality of the final product would be improved. The quality personnel in Company B were somewhat involved with product development personnel; they worked closely with production managers and supervisors. The organization of quality within these two companies was similar to the model described by Kolbeck (1984). They both differed from Kolbeck's model in that quality personnel reported to manufacturing, where Kobeck states that the quality function should be independent from manufacturing. A criticism of this type of organization is that quality can be viewed as the responsibility of the quality personnel and not every employee in the company (Glock & Kunz, 1995; Kolbeck, 1984). However, this did not seem to be the situation in these companies since they had given more of the responsibility for quality to employees, and informants did not perceive that this type of organization caused a conflict of interest between quality and production goals.

Company A and Company D did not have separate departments that deal with quality issues, but rather quality was integrated throughout the organization. Managers at each stage in the process, for example design, pattern making, cutting and spreading, and production, were responsible for ensuring quality at their stage. Respondents at both of these companies made references to suggest that there was overlap between the functions. For example the pattern department and production managers may work together on product specifications. This type of organization was not found to be an indicator of increased operator responsibility for quality as was suggested in the literature. When respondents in each of the companies
were asked if they were satisfied with the quality organization within their company, in each case they said that it was working for them.

Quality Documentation

Of the four companies studied, only company C had a quality assurance manual. The quality assurance manual in company C was used to communicate quality throughout the organization. The manual contained the company's quality goal and included information on sampling procedures, company standard measurements for each garment produced in each size, tolerances, production specifications for each product, classification of defects, and zone locations on each garment. The quality director at company C stated that the quality assurance manual was continually updated. The manual served as a guide to the quality assurance program in the company. Company B stated that they were in the process of developing a quality assurance manual which they anticipated to use as a quality communication tool throughout the company. Respondents in company A recognized the need for a method of communicating quality throughout the company. They had recently developed a sewing manual for operators which included some aspects of quality and was developed to communicate quality expectations to sewing operators. Company D did not indicate a need for a quality assurance manual. Of the four companies, two had a written mission statement in which quality was mentioned. One of the companies had no written mission statement or quality goal. When asked about their company's quality goal, employees at that company did not have a clear perspective on what the company's quality goal was.

Production Systems

Garment production systems varied throughout the four companies studied; however, only two major methods of production were used. Of the four companies studied, company A and company D produced all garments using the progressive bundle system where garment
pieces are in bundles and bundles move through production in sequence. Each operator performs the same operation on each item handled (Glock & Kunz, 1990). Company C used predominantly progressive bundle production with modular production in one manufacturing plant. Company B used mostly modular manufacturing with some production (approximately 30%) using the progressive bundle system. Under the modular production system, operators working in cross-trained groups or work teams produce entire garments. Instead of an operator working on bundles of garment pieces, she or he is responsible for a zone in the modular unit. The zone usually consists of one or two operations, and if there is a problem with one of the zones, operators may expand their zone to help another operator. This system is referred to as the "bump back modular system" and was used at company B. In contrast to the bundle system, garments are produced one at a time. When an operator works on a garment she/he will pass that garment to the next operator who then performs the next step in production of the garment. It can take as little as 13 minutes for a garment to be produced.

Respondents made references to production methods and their relationship to quality throughout the study. These references suggested that there is a relationship between the characteristics of the production system used and quality. All the companies used piece rate as the method of payment for employees. Piece rate describes a compensation system where operators are paid based on the number of items completed. Engineering methods are written for each operation which are used to establish the rate of pay for that operation. Negative attitudes towards the affect of piece rates and quality were expressed by management and supervisors from the companies where the bundle system was predominantly used. Statements which suggested that "piece rates sometimes conflict with quality" were made. Respondents made statements such as:
When you're out there sewing, you've gotta number 1 make rates so that you can take a paycheck home. c12

This probably isn't a good thing, but we are on piece work here, so the girls have gotta do so much to make money, well many times the quality isn't as important to them because if they have to stop - oh this one is a bad one, I've gotta stop and pull it out - that's gonna ruin my piece work. c14

These statements suggest that there is a conflict between achieving a desired level of quality and the incentive method of payment, in which rewards for operators are based on the volume of work that they complete. It should be noted, however, that in all four companies studied when defects were identified they were returned to the operator who had worked on that part. The operator must repair or re-work any defective parts at her or his own expense. This means that the defective work costs operators pay in the long run. Underlying the issue regarding the conflict between piece rates and quality is the assumption that it is the operators fault if their work is not first quality. Inferior quality work may be due to fabric which is difficult to work with, engineering specifications which are not adequately written, or defective patterns.

Production engineers from all four companies stated that they write quality into the production rates and methods for each garment to ensure that operators are paid to achieve a desired level of quality. For example, they would include more time in the production rate for an operation that required an exact match or a close fit, such as the matching of plaid on a jacket. A further criticism of the progressive bundle system was the length of time that it takes for defective garments to be identified. Using this system it may take several days before an entire garment is produced. Therefore, if there is a defect that is not noticeable until the finished garment is viewed, an entire production lot may be almost complete before the defect is noticed in the complete garment.

The company that uses modular manufacturing for the majority of its production (company B) also paid employees piece rates; however, this system differed in that each
modular team was paid an amount per first quality garment produced, and not per operation as is the case in the bundle system. This amount was divided by the number of workers in the cluster. The emphasis in the modular system is not on each individual operation, but rather it is on the finished product. Company B is developing a system in which they can pay bonuses to teams based on their achieving a predetermined quality score calculated over an established time period. Attitudes of respondents' at that company towards the piece rates in the modular system did not indicate the conflict that was expressed with the bundle system. Operators under the modular system see the finished product and are more oriented towards each operation as it relates to the finished product.

As one supervisor stated:

There is a sense of ownership I see in the TSS line as far as quality goes. Their whole attitude is different. They really have a sense of ownership in their product in the TSS line that you don't see on the bundle line. The bundle line you maybe sew the collar of a jacket and you never see the finished jacket, where these girls see the jackets right through and they feel responsible, and when they are having a problem, they want to get it fixed and you don't see that always on the bundle line - if somebody is having a problem, it's her problem. If I have to bring a repair back to the TSS line, they all want to know what the problem is and what needs to be done to fix it.

The above statement suggests that, under the modular system, operators are given more responsibility for the quality of the final product and that peer pressure may have a part to play in achieving a desired level of quality. Also, operators can see how what they do affects the final product. The dynamics of the group seem to influence quality and encourage problem solving which, according to the respondents, was not present in the bundle system. A further advantage of modular manufacturing is reduced work in process and shortened lead times. This can have a positive affect on quality because any problems in production can be identified before the entire production lot has been completed. This was expressed by the quality facilitator of the same company:
What I like about TSS is that instead of waiting for work in progress to come all the way through the bundle line, on TSS we have a finished product in say 20 minutes, and then all we have to do is audit the finished product without having to worry that we've ruined a whole lot of jackets just to figure out the first one wasn't good - we've got the first one done already and we can find out if there are any questions or quirks or problems right there - it really helps quite a bit. c21

Both the quality facilitator and the production supervisor agreed that the quality of products from the modular clusters was superior to the quality from the bundle lines. A disadvantage of modular manufacturing was expressed by the quality director in the company where modular units were used in one plant. He stated that the cost per unit is higher, and it is difficult to justify that higher cost in terms of quality. In addition, the initial capital output for modular manufacturing is extremely high. This is due, in part, to the fact that the modular system requires more machines than the bundle system. One operator may require more than one machine to fulfill her or his responsibilities within the team. According to a respondent, the cost factor and the capital investment of modular manufacturing make transformation to modular manufacturing a difficult decision for management. However, that extra cost factor does not consider the benefits of higher and more consistent quality, and the decreased costs of shorter lead times.

A manager from the company where modular is employed in one plant stated that it was difficult to justify the extra cost and capital investment to make a complete changeover to modular manufacturing. However, in this company, some of the concepts that make modular manufacturing superior to the bundle system have been implemented. The company has developed a quality improvement system throughout the company for both bundle and modular production systems. This system involves tracking the percentage of first quality goods produced by each manufacturing plant and setting continual improvement goals. If the plant reaches 90% first quality goods, then each operator receives a one time $200 bonus. The company has achieved a higher level of quality from this system and has noticed that the
level of quality between plants that use the bundle system and the one plant that uses the modular system is becoming closer. The modular plant is now only tenths of a percent higher in quality compared with 2 - 5% higher before the improvement system was developed. The manager stated that, in some plants, the level of quality has increased from 60% first quality goods produced to over 90%.

**Process Stages Addressing Quality Components**

One of the objectives of this study was to identify the stages in apparel manufacturing in which quality measures are addressed. Throughout the interviews there was a general consensus by respondents that quality must begin at the start of the process and should be built into the product throughout the process.

**Product Development**

Product development is the "Design and engineering required of products to be serviceable, producible, salable, and profitable" (Glock and Kunz, 1995, p. 604). In particular, company C placed considerable emphasis on product development and conducted textile and product testing and experimentation with their processes at the development stage. Garments must pass a series of tests and be able to be reproduced in a production setting before going to full production. As one respondent from company C stated:

> Our philosophy is that we spend a lot of time and resources testing up front to make sure that it is right - we want to make sure something is repeatable before it goes to the field for actual production - we do a lot of extensive testing up front to verify that it is going to be acceptable when it goes to production. c35

Two of the companies studied did not conduct testing at the product development stage, but they did construct sample garments to test for accuracy in the design and pattern. Company D had a manufacturing pattern department where patterns were checked for accuracy in size, ease, and consistency to make sure that any problems with the pattern were
identified before the garment was mass produced. That company paid a 20% bonus to
sample garment makers to look for problems during production and to evaluate how the
garment performed in production. Company A stated that in the past they have had problems
with inferior quality products being identified by retailers once the garments reach their
facilities. In these situations the entire production lot has to be marked down. Another
problem that was found was that choice of fabric by the designer did not always meet fabric
quality standards. That particular problem was solved by having all specifications approved
by the testing department prior to the garment going to production.

Fabric Specifications

Throughout the data both positive and negative references were made regarding the
quality of materials. Respondents from all companies agreed that the quality of materials is
important in achieving a desired level of quality. In one of the companies references were
made throughout the interviews regarding problems with fabric quality. In almost every
interview conducted at this company, comments relating to inferior quality fabric were made.
Problems such as needle cuts, stretching, shrinkage, and fading were reported. When asked
what is done when these problems occur, solutions such as providing operators more time to
check the fabric or re-cut the garment pieces were offered. Respondents at that company
stated that they do purchase sample fabric, but they reported that the fabric they get for
production does not always perform the same way. They noted problems such as shrinkage
and colorfastness with fabric that had previously been evaluated at the sample stage.
Respondents stated that they sometimes have to "unload the goods at a low sale price." This
company did not share fabric specifications with vendors, nor did they have partnerships
with vendors. However, even though numerous references were made concerning poor
quality fabric, references were also made suggesting vendor loyalty due to a long history with
a fabric vendor. A history with vendors seemed to imply good quality goods to some
respondents. Fabric was not inspected on arrival, even though the company did have fabric inspection machines. Further references were made which suggested that a time conflict led to fabric not being inspected. In this company there seemed to be a general acceptance of fabric problems. Problems due to poor quality fabric were being solved by adjusting methods or re-cutting garments; thus, the company was taking responsibility for poor quality fabric from vendors. Respondents recognized that poor quality fabric was a problem, but they did not appear to see any need to change existing practices regarding the purchase of fabric.

Company D was vertically integrated which made communication with the fabric mill easier. Both the fabric mill and the manufacturer had a shared interest in the quality of the fabric. In that company fabric inspection was done before the fabric left the mill, and respondents stated that they have had very few fabric problems.

The other two companies studied have developed partnerships with their suppliers which has improved communication with fabric mills, and thus has made the communication of quality expectations easier. Both of these companies shared fabric specifications with suppliers. A manager at company C stated that the size of the company has given them an advantage in developing partnerships and gaining the responsiveness of fabric mills. Product development and quality personnel at that company worked very closely with personnel at the fabric mills in an attempt to solve problems and improve their process. Personnel at the fabric mill were involved in the product development process. This has involved the sharing of information about both processes which, as the manager said, is a very important part of the partnership. In the manager's words:

*It's a big benefit, the partnership that we think about is that they know our business and we know their business - they are very much linked in with the market, not only do we do research about what's going to be the next seller, what we should be focusing our efforts on, the mills do the same thing - we share information and they also know what it takes to develop a product that's going to*
meet our standards and that's going to perform well for us, so it's a partnership, it's just a very detailed exchange of information.

In particular, that company, along with one of their partners developed a system of "fabric blanketing" which ensures that fabric bolts are sent to the manufacturer in order with the closest shade range possible. The result has been more consistency in color between different garments of the same style. They are now working to improve that color consistency even further by using computerized color matching instrumentation which is networked throughout the company and between the company and its vendor. The goal of the system is to achieve even more consistency in shade matching of the product taking away any subjective judgments which can cause variability. The quality director at the company stated that this process improvement is only possible when vendors and manufacturers work together solving problems and experimenting with the process.

From the data collected at these companies it appears that problems with fabric quality were related to the amount and type of communication between vendor and manufacturer. This is consistent with what was found in the literature (AAMA, 1978; Scheller, 1993). Analysis of these cases indicated that fabric specifications as a method of communicating quality requirements of fabric also may reduce fabric problems. However, the organizational environment also appeared to influence the manner with which problems were dealt. Complacency and acceptance of poor quality did not result in improvements. At the companies where problems with poor quality fabrics were not frequently reported, there were active efforts being made to make changes to the process and the method of doing business in order to make improvements. Analysis of data from these companies revealed numerous references made to various changes which had been made and recognition that previous methods were no longer working.
Cutting and Spreading

Companies varied in the extent of attention given to quality in spreading and cutting. The amount of attention depended on the product being made and the company's standards and specifications for cutting and spreading. One company had very strict standards at this stage. Observations showed that fabric was carefully inspected as it was spread and any defect, regardless of classification, was identified, cut, and constructed into a second quality garment. Cutting room employees in this company spent time making sure that the pattern marker did not deviate from the fabric's grain line. Plaid fabric was pinned to the cutting table to ensure an exact match. This practice meets company standards which require all plaids to match exactly.

Company A did not appear to have such strict quality standards at this stage and observations verified that fabric was not checked during spreading. Cutting room employees admitted that they were too busy and could only catch obvious defects such as a hole in the fabric. Production supervisors from that company made more references to fabric problems during sewing than the other companies.

A problem which was mentioned by respondents in all companies was that of shading and the difficulty in achieving an exact shade match, especially between different bolts of fabric. Two companies addressed this problem at the cutting and spreading stage by labeling garment pieces according to a bolt number so that only matching numbers were sewn together. Respondents at both companies agreed that this system had solved shading problems between garment pieces and reduced the number of completed garments that did not meet quality standards due to poor color matching of component parts.

Production

The differences in production systems between the four companies and their effect on quality has been discussed. Analysis of data found that quality at the garment production
stage was addressed through inspection of garment parts or completed garments, operator responsibility for quality, and engineering specifications. Inspection was a major recurring theme throughout all of the companies and was divided to include both inspection practices and attitudes towards inspection.

**Inspection Practices**

Inspection was the most used method of ensuring garment quality at the production stage by the companies studied. Garment inspection during production (in-process inspection) was carried out at all companies; however, the companies varied considerably in the stages at which inspection was carried out and the extent of inspection. At company A, random inspection was conducted during production when supervisors were timing operators. Supervisors inspected items from the bundle on which the operator had worked. There were no written guidelines as to how many items must be checked or what the accepted quality level was. Supervisors stated that they tried to check five garments from each operator and if they found more than one defect they would pull another three bundles and check each item in all 3 bundles. The random inspection included measuring of the garments according to specifications, checking for fabric flaws, and checking for seam accuracy. The supervisors would also spot check if they were having a problem with a certain operation or fabric. Supervisors stated that operators were told to check their own work; however, one supervisor stated that operators were not very thorough when conducting their own inspection. This may be related to the conflict with piece rates and quality that was discussed at the beginning of this chapter. Managers and supervisors from company A stated that frequency of inspection often depended on how busy they were and how much time was available to supervisors. One supervisor stated that lack of documentation concerning the inspection procedure and defect classification was a weakness with regard to quality in the company. These problems have been highlighted because inspectors from some of the larger retail companies were visiting the company to check
quality procedures. In addition to in-process inspection, respondents at company A stated that there was final inspection of all garments as they were put on hangers before shipping. However, observation of this process suggested that very little inspection was conducted at this stage.

The procedure of inspection differed considerably at company B. Under the modular system, operators were given more responsibility for quality. Garments were inspected within the work team by operators before being boxed. The last operation in the module was to inspect, tag, and box the garment. Supervisors at company B were involved in regular daily audits of garments being produced. The supervisor randomly selected six garments per work team per day. A statistical record of each production line was kept so that a quality score could be attached to each work team. These scores were shared with the work team so that they were informed of their own quality level. Respondents stated that the goal of the quality audits was to gain enough information from the sample to determine what the quality of the entire lot would be. Observation of a quality audit at this company indicated that the procedure was very detailed. The supervisor followed written instructions which outlined what should be checked; a point value was attached to each location on the garment. The audit sheet included garment measurements such as sleeve length or chest width. The supervisor referred to the garment specifications for that style which outlined the size measurements and tolerances for each size. A point value appeared on the audit sheet for possible defects such as under tolerance or over tolerance. A greater penalty was given for a measurement which was under tolerance. Inspection of all seams and stitching was included on the audit sheet also with possible defects identified such as "wavy topstitch" or "uneven collar points." The audit sheet included similar details for all parts of the garment: collar, front, pockets, front closure, sleeves, graphics, cuff/waistband, lining, and back. During the audit the supervisor puts the jacket on to ensure that the lining was not twisted and to make
sure the seam in the sleeve had been closed. In addition, the defects on the audit sheet were classified as being major or minor defects. Major defects must be returned for repair. An example of a major defect may be a pocket bag not closed. The point values for minor defects were totaled and if the value was above a certain score the item would be rejected as being of inferior quality.

Inspection procedures at company C had recently been changed and all in-process inspection had been eliminated. The quality director stated that the system of in-process inspection was not efficient and he felt that it was "putting barricades up in production," and that they were trying to "inspect quality in." The supervisors and operators in that company were now responsible for the quality of their own work. A process improvement system also has been input which rewards all operators in a plant if they reach a certain level of quality. The level of quality was very closely monitored in this company and continual improvement goals were set to achieve a percentage of goods that were produced correct the first time. The quality director stated that the level of quality was currently over 90% and it was continually increasing. He admitted that removing in-process inspection was a gamble, but that it had been a successful endeavor. He stated that the performance from employees was better because they do not have someone "look right over their shoulder and inspect." This has also included a change of philosophy for the company as they have given operators more responsibility for quality. The company continued to conduct final inspections of all garments after they have been given a wet process finish, where, due to the nature of the finishing process, defects were more likely to become visible. The 100% final inspection was used as a means of monitoring the quality level of garments. Hence the quality score could be calculated.

At company D, in-process inspection was conducted at three stages of production. The inspection procedures are documented providing very detailed instructions on how to conduct
the inspection. The inspection was 100% and any deviation from specification was considered a defect. All three inspections were carried out with the garment on a body form which allowed for the garment's visual appearance to be checked thoroughly. The first inspection in the process checked the outside shell of the garment and included inspection of seams, attachments, and clipping of hanging threads. The second inspection included inspection of the lining and any additional operations since the first inspection. The final inspection was the last operation before the garment left the plant and included inspection of pressing, hang tag information, clipping of hanging threads, and checking button attachments. When out-of-tolerance areas were found on the garment, they were flagged with tape and a repair sheet was completed. The garment was then returned to the operator who performed the out-of-tolerance operation to be repaired. Once completed, the repaired garment was returned to the inspection stage and re-inspected. If the repair was not completed in a satisfactory manner, the supervisor was notified.

Two of the companies had distribution centers where goods from the plants were housed before being shipped to customers. Inspection was carried out at both distribution centers; however, the companies differed in the inspection process at the distribution center. One of the companies inspected a 5% random sample of all goods entering the distribution center. The garments in the sample were inspected for "hanger appeal." When asked to define hanger appeal, it was described as any color shading or construction problems. Any garments that were defective were sent back to the plant. Inspection at the distribution center at the other company differed in that the inspection was not to identify defects which occurred in production, but rather to inspect the function that was carried out at the distribution center. At the distribution center employees picked garments, boxed, and ticketed them to fill orders. Inspection at the distribution center was to make sure that the correct number of garments, style of garment, and size were in the shipment and that the garments have been ticketed.
correctly. The quality director from that company stated, that previously when garments were inspected for quality at the distribution center, it had caused problems with goods being held up because defects had been found at the distribution center. As the quality director stated: "You cannot catch bad quality at the distribution center - not if you are going to do service." Now all inspection of that nature for that company is conducted before the goods leave the production plant.

The data revealed that inspection practices differed throughout the companies studied. Respondents in the companies that reported a documented procedure for inspecting garments did not suggest that inspection was not carried out during times when work load was heavy. In the company where there was no documented procedure for inspection, respondents suggested that, when the workload of the plant was high, inspection to achieve a level of quality was not addressed. This could be due to a lack of documentation and organization, and the fact that there was no operational definition for the inspection procedure. Thus, quality did not seem to be as important as meeting production deadlines.

**Attitudes Toward Inspection** Throughout the data for two of the companies, references were made which suggested disadvantages or negative attitudes towards inspection. In one company all employees were in the process of receiving Total Quality Management training and have been taught that someone who was inspecting all of the time was not adding value to the process. References which stated that inspectors were "just a filter" in the process were numerous. When asked if inspection was carried out at the plant, the quality facilitator stated:

> We like to call it auditing, because in our TQM training we learn that anything with the word inspector on is some type of a filter, so we are trying not to inspect quality into the garment, we know that it is there if it can be - if the process can be done right. c21
Respondents from this company stated that they were trying not to inspect quality into the garments, but instead they were trying to make improvements to the process to ensure that poor quality was not constantly repeated. In this company the term inspector had been replaced with the term auditor which to them suggested that the individual who audits was monitoring the level of quality in the process and not inspecting quality into the garment. The term quality audit refers to efforts made to determine whether the process that produces quality is meeting objectives; whereas, the term inspection refers to the measuring or examining of a product's ability to conform to standards (ANSI/ASQC, 1987). The activity carried out by this company was inspection, but the objectives extend further than comparing actual quality with specifications, as they were monitoring the process with the objective of improving the process. Throughout the data for this company many other total quality management terms were used, and more responsibility for quality had been given to operators. Management had given supervisors the responsibility of training operators on quality and allowed them to do more problem solving.

In the other company where negative attitudes towards inspection were apparent, statements were made which suggested that inspection was a "barricade," and inspection of an operator's work by another person reduced the tendency of that operator to develop pride in their work, and the result was a lower level of quality. In the words of the quality director:

I felt in manufacturing we were putting these in-process inspection points, and it was good quality if it got beyond the inspection point - in other words we were trying to inspect quality in, and we were not teaching the right philosophy to all our people. So I said wait a minute we've got the wrong thing here - why do we put barricades up in manufacturing - we are trying to put the work through as fast as we can, and then we, quality comes along and puts a barricade right there and says everything has to go through here and be blessed. Then what are you telling to that sewing person and their pride of workmanship - are we not developing that in? So I took it all out! c31

This company had also transferred responsibility of quality to supervisors and operators and had changed the philosophy of their operations. Both of these companies had noticed an
improvement in the level of quality received from operators since they have changed their philosophy on inspection. Analysis of data from both these companies revealed that many references were made to process improvement and attempts to continually improve the existing process and thus quality.

Engineering Specifications

Production engineers from all companies stated that operational methods affect quality in production. In all cases, respondents stated that they write quality into the work methods for operations. This was done by allowing operators time, for which they are paid, to accurately align garment pieces together. They included "accurate position factors" in the methods and added steps for aligning pieces. One production engineer stated: "We don't shortcut methods - it's cheaper that way - to make everything right first time...." The same engineer stated "Cost is an important factor - we try to engineer the most efficient methods, but not at the cost of quality." A production engineer from another company stated that managers and engineers tried to communicate with the operators, and if the operators had a conflict with time on a certain operation the operators were given more time for that operation.

For most of the companies, product specifications were written according to customers or retailers requirements. Respondents stated that they may produce the same product according to several different quality specifications which have been determined by the customer. The differences among quality levels varied. Some respondents stated that the difference was in tolerances for fit; whereas others stated that they differed in construction requirements such as stitches per inch. This resulted in the companies producing garments of different levels of acceptable quality.

Material/Product Testing

The extent of material or product testing varied considerably among the companies studied. All companies stated that they did conduct material or product tests of some type.
For three of the companies, performance testing was conducted only when they had identified a problem or were working with a new fabric. For example respondents at two of the companies stated that they would conduct wash tests if they had a fabric that they had never used before or sample garments to identify any fabric compatibility or shrinkage problems due to laundering. At one of these companies results of tests for colorfastness were evaluated subjectively since no photographic methods of evaluation existed in that company.

Due to the nature of the products produced by company A, mandatory tests for flammability must be conducted on all fabrics and fabric combinations used by the company. Federal standards have been established which provide strict guidelines for testing fabrics in this product category. In order to be used for children's sleep wear, fabric must meet these standards. If the company uses a new fabric, they must wash it 50 times to represent one years' wear and then test the fabric for flammability. This company did not test for any other characteristics on a regular basis; however, occasionally, sample garments were tested for compatibility of components and colorfastness.

Only one of the companies had an established textile/product testing program with a fully operating performance testing laboratory. That company conducted tests on fabric, products, or parts of products at various stages in the manufacturing process. They tested sample fabric, garments at the product development stage, existing products in the field that are routinely evaluated, and products which have a new manufacturing proposal. A large amount of testing was conducted at the product development stage. Usually, quality personnel would begin testing on product parts and then scale up to full size production garments as the development of the product progresses. The lab manager stated that it is important to conduct tests on a sample which has seams rather than fabric pieces, because even if the sample is not an entire product, a sample with seams will identify how the garment variables will interact and react to various stressors. At the product development stage, testing included
experimentation with the finishing process to achieve a finish that provides good performance characteristics for the garment. The products are tested before and after finishing.

The company conducted both "short" and "long standard evaluation reports" on sample fabric. A short standard evaluation report consisted of limited performance testing because the fabric mill provided fabric performance specifications. A long standard evaluation report consisted of extensive testing of fabrics in both the rigid (before finishing) and after finished state. A purchase status was given to the fabric which indicated if the fabric had been approved or disapproved. The amount of testing that the company conducted on fabrics depended on their history of work with the fabric mill, and whether the company had a partnership with the fabric mill. The tests at this company were conducted according to ASTM and AATCC standard test methods and included tensile strength, tear strength, yarn slippage, flex abrasion, crocking, pilling, and colorfastness to laundering. Test results were evaluated according to standard evaluation scales such as the gray scale for color change and staining and photographic replicas for pilling. The company also had developed some of its own methods of evaluation, such as photographic replicas for evaluating wrinkle resistance of durable press products.

When asked how company performance standards are set for fabric and products, the laboratory manager stated that the company had a long history working with the same product and type of fabric, and thus, they had developed fabric performance histories which were based on the fabric weight. However, because products, fabrics, and finishes are continually changing, the company must evaluate what performance requirements are needed to meet demands of target customers, and also they evaluate performance characteristics of their competitors' products. They take that information along with information on fabric specifications from vendors and develop standards for performance.
Company B was in the process of developing a quality assurance laboratory. This will enable them to conduct more performance testing in the future. Company A had a facility which contains equipment for conducting flammability tests and a washer and dryer. The facility contained no other test equipment. Company D did not have a test facility; however, the company did have a fabric testing facility at the company's fabric mill.

**Business Practices**

Under the category of business practices, relationship with vendors, management philosophy, training, organizational climate, and process improvement were all factors contributing to quality in apparel products. Relationship with vendors has already been discussed in the previous section with fabric specifications. Because of the nature of these themes, both management philosophy and training will be discussed together, and organizational climate and process improvement will be discussed together.

**Management Philosophy and Training**

The literature on quality management philosophies stated that quality was included in all aspects of the organization, and that management must be committed to a continual improvement of quality and provide workers with the resources needed to fulfill their responsibility to quality (Aguayo, 1990; Crosby, 1980). This study found that within the companies studied, management's philosophy on quality and how it is communicated were critical factors in quality improvement. In two of the companies, management clearly recognized the important part that product quality played in the success of their business. Company B had instituted a training program for all employees which had helped to increase their awareness of the importance of quality, helped enhance their diagnostic problem solving skills, and made them more critical of existing methods allowing them to be creative in improving their process. The employees at that company seemed to be aware of their
responsibility to quality. Thus, the organizational climate at company B was one of proactive thinking and creative problem solving. There was no evidence to suggest that production goals took precedence over quality. In contrast, at company A, management's philosophy on quality was not communicated and training of employees was not mentioned. Here, comments were made which would suggest that production goals were more important than achieving product quality. From the data, it would appear that management philosophy is the most important factor contributing to product quality, because without a well communicated management philosophy, many of the other factors which contribute to product quality, such as training, organizational climate, and process improvement are not possible. This finding is consistent with the literature. Gilbert (1987) stated that the direction of the organization must be established and communicated first. Only then can the benefits of other quality tools be achieved.

Organizational Climate and Process Improvement

Throughout the data, references were made which suggested that companies were making efforts to try to improve their process and thus improve the quality of their products. Company C did this by continually monitoring the level of quality output by each production plant. Reports which highlight the major areas of poor quality were distributed to the plants so that they knew which areas to concentrate on in order to improve the quality level in their plants. Company B was beginning to monitor the level of quality in their plants; they also shared reports with plant employees so that improvements could be made.

In company C trouble shooters were employed to solve problems with fabric or garment construction. This job involved solving problems and conducting follow up on solutions to verify the effectiveness of the solution. An example was a problem with needle cutting in fabric which appeared during production. The person conducting the investigation found out what was causing the needle cuts. It could have been due to inadequate lubricant used on the
fabric to facilitate sewing or it could have been failure to change sewing needles often enough. The employee talked to both the fabric vendor and personnel at the plant to check the process. This individual must have a good working knowledge of both the garment production process and the fabrication process. The same company had field problem solving teams who worked with problems in the plants. A manager from that company stated that since they have used the team concept to solve problems, they have noticed improvements and increased enthusiasm from their associates who are trying to surpass goals instead of reaching a plateau as was usually the case in the past.

In company B, the total quality management philosophy was being used to create an environment which was conducive to continuous improvement. Instead of asking management, supervisors were encouraged to attempt to solve problems that operators may have. Quality personnel at that company stated that communication has increased within the organization. Employees were more informed about the entire process and the effect of their work on the entire process. The quality facilitator at that company admitted that it was much easier in the modular manufacturing setting because operators had contact with the finished product.

Grounded Theory

Grounded theory is a procedure where analysis of naturalistic data is carried out through the inductive utilization of open coding methodologies. Through extensive analysis of data, abstract meanings and patterns emerge from the data forming a grounded theory (Strauss & Corbin, 1990).

The data from this study was descriptive in nature. The main objective of the study was to describe quality assurance practices in the companies studied and compare these practices with those found in academia. However, during extensive analysis it became apparent that
some relationships existed between the main themes in the data. The themes (listed on page 51) were divided into categories; within the categories, factors that contribute to quality were listed. Because a comparison was not made between the quality levels of any of the products made by these companies, quality in this discussion relates to the presence of process improvement and comments made by informants relating to the quality of the product. An operational definition for process improvement has been defined as the monitoring of a process resulting in the implementation of changes to improve quality.

The themes are presented in a model of the factors contributing to process improvement (See Figure 2). In the model, business practices appears at the top because it was found to be critical in achieving quality. The other categories depend on business practices before they can contribute effectively to quality. The model highlights interrelationships and communication among categories. Broken arrows indicate relationships in which communication is present. The circle must be complete before process improvement can exist. If a factor or appropriate communication is not present, then product quality may be compromised. It is important to note that the manner in which quality is addressed at the process stages will affect process improvement. If quality is not addressed from a process improvement perspective or if communication does not exist, then process improvement will not be achieved. Thus, the factors cannot stand alone. The underlying assumptions of this model are that quality is the responsibility of all employees in the company and that quality penetrates throughout the company.
Figure 2. Grounded theory model of the factors contributing to process improvement.
The interrelationships existing between factors are critical to this model. Some of the factors appear to be necessary in achieving a desired level of quality in products; these may be referred to as primary factors. These are quality documentation, production systems, quality in product development, fabric specifications and vendor relationships, standards and specifications, management philosophy, training, and process improvement. In the four companies studied, these factors were most important in achieving quality improvement. The other factors were found to be contributors to apparel quality, but were not considered as crucial to the development of quality. Production systems is listed as being a primary factor in apparel quality. The scope of this study cannot extend to making a comparison between different production systems; however, the study did find that companies differed in the methods that they employed to ensure quality during production, and that the methods used may affect the quality of the final product. The grounded theory model reinforces many of the theoretical perspectives revealed in the literature. The philosophy of total quality management which promotes continual improvement of quality and the permeation of quality throughout the organization (Aguayo, 1990; Deming, 1982) is reinforced in the model. The importance of management commitment to quality was a dominant theme in the literature and was also found to be a major component of the grounded theory model (Crosby, 1980; Gilbert, 1987).

**Relationship Among Themes**

Throughout the data analysis, relationships among the emergent themes were revealed. These relationships are depicted in the model of the factors contributing to process improvement (See Figure 2); they help to explain the factors that contribute to achieving a level of quality in the four companies studied.
Analysis found that company size affected a company's relationship with its vendors. Larger companies had more influence over vendors and were more likely to form partnerships with vendors. The data indicated that those companies that had partnerships with vendors and used fabric specifications to purchase fabric seemed to have fewer problems with fabric quality. There was also a relationship between a company's history with a vendor and the assumption that the vendor supplied them with good quality materials. Individuals at one of the companies associated vendor history with good quality.

The presence of quality documentation, both in the form of a quality assurance manual or written guidelines for executing quality procedures such as inspection, reduced the likelihood that quality practices were ignored when deadlines had to be met. There seemed to be an attitude that un-documented practices were not set in stone and therefore could be ignored, because they were not important. Employees at the company where a quality assurance manual was used appeared to have a clear perspective regarding the quality goals of the company and how quality was achieved. Employees at another company, where little or no documentation exists, seemed to be un-clear on the company's quality goal and showed more hesitation when addressing how quality is achieved in products.

The organization of quality within the companies seemed to influence methods by which quality was communicated throughout the company. In the two companies that had personnel responsible for quality (company B and company C), there was more communication of quality throughout the company. Although there was personnel who specifically dealt with quality, the importance of quality was recognized by personnel in other functions such as cutting and spreading and production.

At company B, the person in charge of quality used the title of quality facilitator. He preferred this title because he felt that his responsibilities were to communicate quality requirements to other functions in the company or to help bring two departments together
when dealing with problems. At that company, the quality personnel were not responsible for assuring quality, but rather, they were responsible for problem solving and communicating quality requirements. The literature suggests that a separate department for quality within the company implies that quality is only the responsibility of that department and not all employees. This was not found to be true for the four companies studied. In the companies where quality was integrated throughout the company, it was not clear that quality was the responsibility of every employee. There was less documentation and communication of quality at these companies.

These observations reinforce the idea that management philosophy is a critical aspect of quality. In order for an integrative quality organization to be effective, the appropriate management philosophy must be present, and positive attitudes towards quality must permeate throughout the company. The type of quality organization alone did not seem to have much effect on quality practices.

In the companies where the management philosophy was clearly communicated, employees seemed to comprehend the priorities of the company and were more focused towards process improvement. In two of the companies, a total quality management philosophy had been adopted, and responsibility for quality had been passed down to operators and supervisors. More references to continuous improvement were made in these companies. Respondents from these companies also made more references about receiving training and also had a recognition of the importance of employee training.

**Course Content Study**

Forty-one letters requesting course information were sent to faculty members who teach quality assurance/textile testing courses in universities throughout the United States. Twenty-five responses were received which represents a 61% response rate. From the 25 responses,
18 (72%) were usable. Seven of the responses were not usable because the information provided related to courses other than textile testing/quality assurance. In most of these cases the information that was sent was about apparel production courses where quality issues were addressed. That information was useful when received in conjunction with quality assurance syllabi but was not the focus of the study. The amount of information received from faculty varied. In some cases, in-depth information about the course and assignments were provided. In other cases only a brief overview of the course was provided. The discussion of the courses is based on the information provided. It should be noted that some topics that were not mentioned in the information provided may, in fact, be covered in the course.

The content of the 18 courses was described using a coding guide which contained all of the topics from the syllabi. These topics reflect many of the same topics discussed in the textbooks reviewed in chapter two. In the following discussion I describe the content of the courses using the coding guide as an outline.

General Characteristics of the Course

Table 1 shows the general characteristics of the courses. In 4 of the 18 courses, quality assurance or textile testing was included as part of another course. In all four courses quality assurance was part of a textile science course, and the proportion of time that was devoted to the quality assurance or textile testing portion of the course varied from approximately 25% to approximately 75% of the course. In these courses textile testing was addressed briefly and the objective was to familiarize the students with test methods, equipment, and the concept of textile testing.
Table 1. General Characteristics of the Course. (n = 18)

<table>
<thead>
<tr>
<th>Condition</th>
<th>YES</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is Quality Assurance/Textile Testing combined with another course</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>Lab</td>
<td>18</td>
<td>100</td>
</tr>
<tr>
<td>Lab Report</td>
<td>16</td>
<td>89</td>
</tr>
<tr>
<td>Physical Performance Testing</td>
<td>18</td>
<td>100</td>
</tr>
<tr>
<td>Technical Report Writing Taught</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Group Work</td>
<td>8</td>
<td>44</td>
</tr>
</tbody>
</table>

All of the 18 courses included laboratory work and physical performance testing of fabrics or products. In all but two of the courses a laboratory report was assigned to students. The reports varied in nature and workload. In 8 of the 18 courses students worked in groups to perform tests and project work. In the other ten courses laboratory work and assignments were an individual effort. In 3 of the 18 courses students were given instruction on technical report writing. For three of the courses technical report writing was one of the course objectives.

Nature and Purpose of Testing

In most (78%) of the courses, testing was conducted on samples cut from fabric yardage purchased by the student (see Table 2). Both furnishing and apparel fabrics were used. Of the 14 courses that conduct tests on fabric, six related testing of fabric to an end-use, and three related testing of fabric to a product. The information for the five remaining courses did not mention testing of fabric in relation to an end-use or a product, but rather the focus was on following the actual test procedures and using the equipment. In four of the courses testing was conducted on products. Information received for such courses revealed that students purchased products (usually at lower price points) and cut samples from the purchased products. Usually at least three identical products were purchased. In these
courses, students also tested the seams of the garment, and in one case, breaking strength tests were conducted on sewing thread, zippers, and Velcro.

Only one course addressed quality assurance and textile testing in relation to product development; however, it should be noted that in some cases that information was addressed in other courses. In three of the courses, the limitations of textile testing as a method of evaluating the performance of textiles or apparel products was mentioned. In these courses the limitations of textile testing were discussed in terms of reliability and validity of test results, and the advantage of textile testing over wear testing and vice versa.

Table 2. Nature and Purpose of Textile Testing. (n = 18).

<table>
<thead>
<tr>
<th>Tests conducted on fabric</th>
<th>YES</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tests conducted on entire product</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>Mention of Product</td>
<td>6</td>
<td>33</td>
</tr>
<tr>
<td>Testing/evaluation in relation to end-use</td>
<td>9</td>
<td>50</td>
</tr>
<tr>
<td>Product development</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Limitations of textile testing</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Tests for fabric/seam compatability or any seam tests</td>
<td>5</td>
<td>28</td>
</tr>
</tbody>
</table>

**Standards and Specifications**

Most of the courses (94%) addressed standards and the standards organizations that develop specifications and methods for evaluating textile product quality (see Table 3). Among these organizations, the American Society for Testing and Materials and the American Association of Textile Chemists and Colorists were mentioned most often. Test methods developed by these organizations were used in most of the courses described. In 10 of the course descriptions, specifications were mentioned. The focus in each of these 10 courses
was on what specifications are, what they are used for, and how they are developed.

Tolerances were mentioned in only two of the courses; however, they may be discussed, along with specifications, in more of the courses. In five of the courses, students were required to write specifications for products.

Table 3. Standards and Specification. (n = 18)

<table>
<thead>
<tr>
<th>Standards and standards organizations</th>
<th>YES</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specifications</td>
<td>17</td>
<td>94</td>
</tr>
<tr>
<td>Tolerances</td>
<td>10</td>
<td>55</td>
</tr>
<tr>
<td>Students write specifications</td>
<td>11</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>28</td>
</tr>
</tbody>
</table>

Industry or Organizational Perspective

Only four of the courses addressed quality assurance or textile testing from an industry perspective (see Table 4). These courses addressed the function of quality assurance and quality control and the organization of quality assurance or quality control programs in industry. In some cases students gained experience developing a quality assurance program.

Table 4. Industry or Organizational Perspective. (n = 18)

<table>
<thead>
<tr>
<th>Organization of quality assurance or quality control</th>
<th>YES</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mention of quality assurance or quality control program</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>Concepts of quality</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>What quality is and why it is Important</td>
<td>9</td>
<td>50</td>
</tr>
<tr>
<td>Overall industry orientation</td>
<td>6</td>
<td>33</td>
</tr>
<tr>
<td>TQM</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>Role textile testing plays in quality assurance</td>
<td>3</td>
<td>17</td>
</tr>
</tbody>
</table>
Three of the courses addressed the role that textile or product testing played in quality assurance in industry. General concepts of quality in relation to fabric and product serviceability were addressed in half of the courses. Total quality management philosophies were addressed in two of the courses. Information received for other courses suggested that this area is often addressed in other classes.

**Conducting a Quality Audit**

Students gained practical experience conducting and interpreting results of a quality assurance audit in only one of the courses. In that course students determined a sampling plan for a product assortment or a production lot, gained experience categorizing defects and determining the defects per hundred units for a product, and related the results of the audit to specifications and company standards.

**Statistical Analysis and Sampling**

Statistical analysis of test results and procedures for selecting a sample from a product or bolt of fabric were addressed in 11 of the courses. Statistical analysis varied considerably throughout the courses. Basic statistical methods, such as calculating the mean, median, mode, and standard deviation, to describe a set of data were taught in most of the 11 courses. In one of the courses more in-depth statistical methods were taught, such as analysis of variance and control charts. In another of the courses, statistical process control, including the seven tools of quality were taught. In these courses, statistical methods were applied to the data collected from textile performance testing.

**Color and Color Matching**

Color matching and shading was addressed in 4 of the 18 courses. In these courses color matching was addressed from an industry perspective and topics included: the physics
of color, dyes and colorants, color matching, instrumental color measurement, color
tolerances, and metamerism.

Student Projects

Details regarding student projects or assignments were not included with eight of the
syllabi. In some cases, the presence of a lab report or project was mentioned, but no details
were given. Projects where details were available ranged in complexity. Some projects were
the effort of a group and others were an individual effort. Five of the projects consisted of
laboratory assignments where the student conducted tests on a single fabric or multiple
fabrics according to several test methods, and reported the results in the form of a technical
report. The other five involved a description of a target market in terms of consumer
preferences for a certain product, specification development for that product and target
market, and performance testing in order to evaluate suitability of a product or fabric for its
day-use. In two of the courses, the project was divided into two parts. First, the students
described the target market and product. Then they wrote fabric and production
specifications for that product; these specifications included the standard test method used to
evaluate the characteristic in question. Finally, they specified the desired test result with
tolerances. For one of the projects the students also described an assortment plan detailing
how many units for each color and size combination would be found, and a sampling plan
indicating how many products of each size and color should be audited. For the second part
of the project students conducted the quality assurance audit that they had outlined in the
previous paper. This included an interpretation of the results. Another class project allowed
students the option of conducting a lab test or wear test on a product. Of the projects that
were described, most were laboratory reports where the student conducted multiple physical
tests on fabric and evaluates the result.
Conclusion

The overview of the content of textile testing courses provided information which indicated that the orientation of most of these courses was towards physical testing of materials. The focus was technical rather than theoretical. In many of the courses the main objective was to introduce students to laboratory test methods in textiles with little emphasis on an end product, consumer, or end-use. Standards and standard organizations were discussed in almost all of the classes. There was very little orientation towards industry in the courses studied, and typical industry practices, such as conducting a quality assurance audit or inspection were rarely included in these courses.

There are limitations in this analysis which should be considered. The method of collecting information on courses, i.e. using course syllabi, is dependent upon how thorough and detailed each syllabus was. The data were analyzed using the information provided for each course; however, that information may not be complete in each case. Some of the syllabi used in this study were very detailed, while others were brief, and probably did not represent a full and accurate portrayal of the course.

Comparison Between Industry and Course Content Results

One of the objectives of this study was to compare the apparel quality assurance practices found in industry with those found in academia. Analysis of data from the four industry case studies found that company characteristics, process stages addressing quality components, and business practices were important factors in achieving a desired level of quality. Figure 2 shows the grounded theory model of the factors contributing to process improvement. The category process stages addressing quality characteristics is most closely related to the information covered in quality assurance/textile testing courses. Within that category, quality is addressed at different stages in the apparel production process.
Quality at the product development stage involved ensuring the quality of materials, designs, patterns, and construction methods. All of these variables contributed to the quality of the finished garment. Textile testing was used at this stage to evaluate the performance of products which were in the developmental stages. Quality personnel from the companies studied stated that testing entire products or parts of products gave the most realistic evaluation of performance at this stage. By testing products, an evaluation of the interaction between product parts was possible. The seams of a garment can be evaluated also. Quality personnel at one of the companies stated that by testing products, the design, pattern, and material could be evaluated for performance simultaneously. The industry data indicated that the end-use, customer, and the final product were always the main considerations when conducting performance testing.

The data collected from textile quality assurance classes indicated that testing on products was practiced by only 4 of the 18 courses analyzed; however, in half of the courses, testing was conducted in relation to an end-use or target consumer. A review of the tests conducted on fabrics or products in courses indicated that testing for all aspects of performance was carried out. A comparison with the tests, which were found to be conducted in the companies studied, showed that the list of tests was less comprehensive and focused more on the interaction of materials, the appropriateness of the care label, and performance related to consumer satisfaction.

Quality during production was important for all of the companies studied. Quality was found to be addressed in product specifications, engineering specifications, inspection practices, and company standards. Some of these aspects of quality were addressed in the quality assurance courses studied. In some of the classes, students gained experience writing specifications and conducting performance tests according to their specifications. These students will gain an appreciation of the difficulty in writing specifications. Specifications
were found to be important in communicating quality in the companies studied, and can greatly influence the costs involved in garment construction and the quality of the final product. Therefore, experience writing specifications may be helpful to students seeking management positions in industry.

Inspection was found to be a method of achieving quality in all of the companies studied. Negative attitudes towards inspection were expressed by some employees; however, inspection was used at all companies as a method of assuring quality during or after production. The inspection conducted at the companies included the measuring of garments, classification of defects, and in some cases zoning of garment parts. Only one of the quality assurance classes reviewed included quality auditing as part of its content.

Quality also was addressed in engineering specifications. This topic was not covered in any of the courses; however, it is thought that engineering specifications are addressed in apparel production management and engineering courses.

Color and color matching problems were reported in all of the four companies studied. Achieving a consistent color shade between product parts, a color that matches a standard, and consistency in color were all reported as factors in reaching a level of quality for a product. Companies varied in the methods they used to achieve color consistency and shade matching. Methods ranged from highly subjective visual matching to the use of computerized color matching instrumentation. Only four of the courses analyzed address color matching. Information from the case studies suggests that students who are more aware of the dimensions involved in color matching may be able to help solve what appears to be an industry wide problem.

The overall industry orientation of the courses reviewed was low. Only four of the courses addressed the organization of quality assurance or quality control within organizations, or quality assurance programs. Only one of the companies studied had a
documented quality assurance program; however, two of the companies recognized that the absence of such a program was a weakness and they stated that they will be developing a documented program in the future. Students who are familiar with documenting quality practices, such as classification of defects and zoning for a particular product and target consumer, may have valuable skills to offer industry. From the sample of companies studied, it appears that industry personnel are realizing that a documented quality program is an important tool. A documented quality assurance program can be used to communicate quality expectations throughout a company. Overall, the industry case studies found that there is a recognized need in industry for quality practices. Graduates with a knowledge of quality assurance practices in industry may be valuable to the industry in its attempt to improve the quality of apparel products.

In conclusion, the orientation of the course syllabi was of a technical nature. Some courses were oriented towards only the technical aspects of textile testing which is not realistic when considering industry practices. While the technical aspects of quality assurance are valuable in industry, they only form a small part in achieving a quality product and may address technical aspects that are rarely included in materials testing practices found in industry.
SUMMARY

Conclusion

An understanding of quality assurance practices within the four companies studied allowed the researcher to form opinions regarding the factors that affect quality. This study has provided information on how these companies achieved a desired level of quality for their products. Each firm had developed a product definition of quality which was made operational through the use of production specifications and in some cases materials specifications. Some definitions were more specific than others which depended upon customer requirements and the company's quality standards.

The results have highlighted that, in order for a quality product to be produced, attention must be given to quality throughout the entire production process. Emphasis on quality at the beginning of the process is of particular importance. This finding reinforces the theoretical perspectives of the literature (Boznak, 1994; Cooklin, 1991; Mehta, 1992)

This idea is consistent with the Taxonomy of the Apparel Merchandising System (TAMS) proposed by Glock and Kunz (1995) which describes the merchandising system and identifies how it interacts with other elements of the apparel firm. TAMS highlights the integration of quality within the merchandising function. Although this study did not address merchandising and product development in detail, it did reveal that quality was addressed at these stages, and highlighted that in order to achieve a quality product, quality at these stages must be addressed. At company C, quality was addressed at both the preadoption and postadoption product development stage. This was achieved through materials and product testing, and involved the joint efforts of product development personnel, quality personnel, and fabric vendors. The appearance and performance of fabric is critical to the products produced at that company; therefore, the fabric and the finishing process must be tested
before the product can be approved. However, at the other three companies, quality during product development was concentrated at the postadoption stage.

Within TAMS, quality standards are addressed under the "business plan" which is a component of a company's strategic planning. Quality was addressed at this stage at both companies C and D. At both of these companies, company quality standards were incorporated into the companies mission statement. Quality also appears under the category of sourcing strategy in TAMS. A company's sourcing strategy will determine how the company purchases its raw materials for production. Quality within this category has been addressed in the factors identified as: relationship with vendors, fabric specifications, and production. These factors were all found to be contributors to quality, and there appeared to be relationships between these factors and a company's ability to achieve a certain level of quality. The quality implications of TAMS are consistent with those highlighted by the grounded theory model of the factors contributing to process improvement (Figure 2). In both of these models the integrative nature of quality within the apparel manufacturing company is displayed. Underlying assumptions for both of these models are that quality is integrated throughout the company and that quality is the responsibility of all employees.

The quality level of materials, as was outlined in the literature, was an indicator of final product quality. Some companies recognized this and were making efforts to increase communication and share information with suppliers. Other companies accepted the level of quality as provided by suppliers and did not purchase fabrics using specifications. A reactive approach to quality was apparent at one company where few problem solving or prevention efforts were observed. This resulted in quality problems throughout the production process, and in some instances, goods were sold as second quality for a lower price because of these inherent problems.
Some of the companies were, however, focusing efforts on process improvement. Active efforts to make changes to the existing system were observed at two of the companies. An in-depth analysis of what factors lead to process improvement in these companies lead to the formulation of some opinions. Management philosophy and training was a factor in both of these companies; both of these factors are critical if process improvement is to take place. Process improvement is necessary for long term improvement of quality. In both cases, management philosophies were communicated to employees throughout the company by means of documentation. This documentation resulted in a consensus of perspectives from employees. Employees recognized a shared goal; all of the individuals who were interviewed in these companies were aware of the goal. These findings are in agreement with the literature on quality management philosophies (Gilbert, 1987; Rao, 1985).

Giving operators more responsibility was also a factor in process improvement. References to pride in workmanship were made in relation to quality. Statements were made which suggest that quality can be achieved only if individuals take pride in their work. The amount of responsibility given to operators depended upon the production system and the management philosophy. Positive factors which affected pride were reported as being contact with the final product, increased responsibility, communication and feedback, and peer pressure. Negative factors affecting an operators pride in workmanship were reported as in-process inspection, lack of contact with the final product, piece rates, and productivity pressures.

A comparison of the industry results with the course content results found there to be a lack of product and industry orientation throughout the course syllabi reviewed. In order for students to be better prepared for the industrial setting, textile testing and quality assurance courses should be more practical in their approach to the subject. The case studies of four apparel manufacturing companies found that only one of the companies conducted extensive
textile testing; however, other aspects of quality were used throughout. For example, the use of inspection and quality audits were common industry practices. Inspection as a method of achieving apparel quality has received negative opinions in the literature; however, the results of this study found that it was used by all companies. Companies varied on their approach to inspection and auditing, and the study highlighted that inspection can be used as a method of process improvement if the correct approach is taken. Very few of the course syllabi reviewed included quality audit or inspection information or experiences.

The main focus of the course syllabi reviewed was on the technical aspects of laboratory testing. Much of that testing was conducted on fabric yardage. This approach may not be a realistic representation of what students can expect to see in an industrial setting. For example, at one of the companies where textile testing is conducted, a large portion of the testing was conducted on portions of products to gain information on the interaction of variables within the product. Much of the testing at that company was conducted at the development stage, and therefore design, pattern, construction, and fabric aspects were being tested. If products were tested in classes, students could gain an appreciation of how these factors interact. Throughout all of the discussions with industry personnel, references were always made to the target consumer and how performance characteristics relate to that consumer. Many of the course syllabi studies included a target consumer or end-use. Based on the industry study, this is considered essential in the evaluation of apparel performance characteristics.

In order to be representative of industry practices, apparel quality assurance classes should address the following subject areas: target consumer and her/his product requirements, testing on a product, experience in writing specifications, the relationship between textile testing and quality assurance, textile testing and assuring quality at the product development stage in the process, and conducting a quality audit.
Based on data from the four companies studied, a grounded theory model has been proposed (Figure 2). This model may used to identify the integrative nature of quality within apparel manufacturing companies. The model highlights the relationships which exist within the company and shows how they may impact upon process improvement and meeting quality standards. The grounded theory model of the factors contributing to process improvement can also be used in curriculum development as a framework for program development in the areas of quality assurance and product development. The model highlights the major areas that should be addressed and the interrelationships between these areas. According to the grounded theory model, a program of study which would prepare students for quality assurance positions in the apparel industry should included the following classes: total quality management, interpersonal/communication skills in industry, textile science, textile quality assurance, product development, production engineering, statistical methods for quality and productivity, and continuous quality improvement of processes. A further suggestion, based on the model, would be to include classes which are more comprehensive in nature and incorporate more than one of the above areas. For example, one such class could incorporate product development, quality assurance, production engineering, total quality management, and interpersonal skills. Courses of this nature may provide students with a more realistic approach to learning about quality and how it is practiced in the industrial arena.

Limitations

The results of this study are based upon analysis of data from four apparel manufacturing companies and 18 course syllabi. Such a small sample of apparel manufacturing companies may not be representative of apparel manufacturing companies in the United States. Although a case study protocol was used, identical methods of data
collection were not used throughout all four case studies. At one of the companies, managers preferred to lead the interview rather than the interviewer asking questions based on the interview guide. In these instances, the interviewer was able to ask most of the questions on the guide. At another company, management requested that the interviews would not be tape recorded, and therefore less information was documented from that company.

The sample of 18 textile quality assurance courses was smaller than anticipated, and the information gained from these syllabi cannot be generalized to all such courses taught in the United States. The method of collecting information, using course syllabi, may not provide a true representation of what is taught in these courses.

**Recommendations for Further Research**

This study was descriptive in nature and provided a base of information for a more in-depth study. Each category (company characteristics, stages that quality is addressed, and business practices) could be studied individually. Business practices were an important factor in achieving a level of quality. A more in-depth study exploring the role of management philosophy and corporate culture on achieving quality would be useful. Likewise, a study which compared production systems and their relative affects on achieving quality would be valuable.

The information gained from this study could be used in the development of a quantitative survey instrument to conduct a larger study consisting of a more representative sample of apparel manufacturing. Such a study would be useful to the apparel industry, since the results would be generalizable and statistical inferences could be made.

This study did not provide in-depth information regarding apparel industry needs from graduates in the area of quality assurance. A more representative study of industry requirements for graduates in the area of apparel quality and production management would
be useful to academicians attempting to prepare undergraduate students with little or no industry experience. A study which explores the skills and knowledge necessary for success in that area would be beneficial to programs preparing graduates for the apparel industry. Apparently textile science faculty are unaware of industry practices related to quality assurance and the relationship of materials testing to production and product development. The lack of industry perspective found in the quality assurance classes reviewed suggest that more research is required which can help to bridge the gap between industry and academia.

Based on these comments and the grounded theory model of the factors contributing to process improvement the following hypothesis are proposed for further research:

- A relationship exists between product development, fabric specifications, and relationship with vendors. The relationship between these factors will have a positive impact on the quality of goods produced.
- There is improvement of measurable quality characteristics when companies develop relationships with vendors.
- The presence of quality documentation influences employees definition of quality and contributes to process improvement.
- The grounded theory model of the factors contributing to process improvement can be applied to other cut and sew industries and offshore apparel manufacturing facilities.
REFERENCES


Boznak, R. G. (1994, July). When doing it right the first time is not enough. *Quality Progress*, pp. 74 - 78.


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Finally, I want to thank my family and Dan for their constant encouragement and support throughout my graduate studies.
CASE STUDY PROTOCOL

The purpose of this study is to find out quality assurance procedures at each company. The study does not compare quality of products between the companies studied, but rather aims to document how they achieve their desired quality level. The study concentrates on quality assurance practices, the functions carried out by the quality assurance department, and integration of quality throughout the garment production process.

- If product development is carried out at the same location, how much input does the quality assurance department have. What quality practices are performed at this stage?
- Is textile testing carried out? When in the process and what tests?
- How are incoming raw materials dealt with? purchased?

The objective of each case study is to get as much information on the workings of quality assurance department within the company as possible this information will be gained through:

- **Company Demographics** - use the questionnaire that I have constructed to ask the first contact person about the company.

- **Plant observations** - looking at how operations are performed. Take notes using tape recorder. Comments such as operation performed slowly and precisely. Extra steps in process to contribute to quality such as seam busting. Manufacturing specifications to get an idea of tolerances used. Try to ask pertinent questions when being shown the plant. Ask if I can take photographs during the tour, and find out what the procedure should be - should I ask every person that I am photographing.

- **Analysis of quality documentation.** Looking at the companies quality assurance manual if they agree. Filling out standard form that I have and adding any additional information. Any other documentation that is available.

- **Interviews of quality assurance personnel.** Using the semi-structured interview instrument as a guide. Remember to explain that the questions may be
repetitive and ask for any additional information that they think should be present. Listen to the answers to questions to determine if they are providing any additional questions that are not on the instrument. Make revisions to the instrument after each interview.

NOTES:
- Make sure that I get a consent form from each company. Take extras and ask the contact person if they have sent it back.
- Ask about taking photographs
- Ask about tape recording the interview
- Give the interviewees a letter about the study.
PART 1: Demographic information about firm

Location

How many manufacturing plants does the company have

How many people employed by the company and in this plant

Could you give me an estimation of the company’s gross income

Is the company publicly or privately owned

What goods do they produce

Who buys the product

Is the product distributed regionally, nationally, or internationally

What is the price point of these goods i.e. low-end, budget, moderate, better, designer

Do they source materials - do they have any criteria for suppliers
  how do they check the quality of suppliers goods

What system of manufacturing do they use i.e. traditional bundle, modular, UPS

How long have they been using that system
Degree of satisfaction with the system
Any plans to change the system
DATA GATHERING INTERVIEW INSTRUMENT - PART 2

1 - JOB

1. Could you start by telling me about your job responsibilities, and possibly give me a run down of your typical day (if there is such a thing!)

   How long have you been working in quality

   How long have you been working with this company

2. How did you learn your job

   Probe - On the job Training?
   Training from other employers or formal training

3. Did you have any previous experience or training/skills or education related to this job

   If Yes - please explain

4. What skills or educational background do you think are necessary/helpful for individuals doing this job

2 - COMPANY QUALITY MISSION

5. What is the importance of product quality in this company or how is product quality related to the mission or work of the company

   How do you define product quality

6. Does the company have a quality goal or mission

7. How do you think that the quality mission is achieved

   Probe quality of raw materials
partnerships with suppliers
inspection
textile testing
product testing
engineering specs
employee involvement
management involvement

*ACHIEVING A CONSISTENT LEVEL OF QUALITY - HOW?

8. At what stages of manufacturing do you think that quality is addressed

9. What is the title given to the department that deals with Quality Assurance and/or textile or materials testing

   Do you do textile testing

10. What functions other than textile testing does that department perform

   **Probe** Involved in Product development
   manufacturing/engineering specs
   inspection
   administration
   dealing with complaints, returns, or production problems

11. At what stage in the manufacturing process is textile testing carried out

3 - FABRIC & RAW MATERIALS

12. When raw materials come into the plant are they inspected or do suppliers inspect
If yes - Do you use a system for fabric inspection - such as the 4 point system where you calculate total points/100 yd.

13. Are fabric or other materials specifications shared with suppliers

14. Who writes the specifications for fabric or other materials
   
do they include standard test methods with a desired result and tolerances
   
if so, is fabric tested using these test methods when it arrives at the plant

15. Is sample fabric tested before it is used in production and before a large amount is purchased i.e. if that fabric has never been used before or if the supplier is new
   
   if yes - what tests are given
   
   Probe Fabric tests:
   
   count
   weight
   yarn no.
   fiber content
   color matching

   Performance:
   strength
   abrasion resistance
   dimensional stability
   colorfastness to laundering
   resiliency etc.

4- PRODUCTS & PRODUCTION

16. Are specifications written for each product produced
   
   who is responsible for writing specs
   
   what do they include
17. Do you perform any tests on finished products (i.e. product testing)  
   **if yes** - When in the process  
   How do you select products for product testing (randomly, every garment)  
   What tests do you perform on products list tests  
   Do you use standard test methods such as ASTM and AATCC TM's  
   How do you decide if products that have been tested are acceptable  
   Are these tests destructive tests - how do you determine that number(%)  

18. What is your basis of accepting or rejecting entire production lots  
   **Probe** - Do you take a sample of a finished lot and test or inspect  
   How do you select that sample i.e. random, using sample tables such as Military Standards  
   How do you analyze the results of these tests i.e. do you calculate a percentage of defects. Do you have an accepted quality level  

19. Do you test for compatibility of components i.e. trims, buttons, zippers work with the fabric and do not cause any problems in the finished product  
   What tests do you conduct
When do you conduct these tests - at the product development stage?

20. Do you test for consistency in size i.e. all size 8 are within certain measurements
    What are your tolerances

21. When is visual inspection carried out i.e. after each operation
    before an operator works on a part
    before parts reach a bottleneck
    after the garment is complete
    Is every garment inspected

22. Who inspects garments i.e. production operators or inspectors

23. What training do they have

    Do you have a description to identify defects or defectives for example: what is considered to be a defect, a critical defect

24. Are defects classified according to location on the garment (zones) or by type of defect i.e. description of defect

    if yes - can you explain that classification system

    Do you have a system to determine first quality, irregular, third quality etc.

5 - PRODUCT DEVELOPMENT AND ENGINEERING (I.E. QUALITY INTEGRATION)

26. Are you involved in product development yes/no
    if yes - how do you contribute
    choice of fabric
    compatibility of components
production operations

27. Are you involved in writing engineering specifications or operational details

28. Do you think that engineering specs/operations are written to achieve a certain level of quality - for example are they written to account for extra time to ensure that difficult operations are carried out exactly and error free.
   
   if yes - can you name some of these operations

29. Are there any stages added to maintain a certain quality level i.e.. seam busting, capping of sleeves

30. How does the firm integrate production goals with quality goals

   Is there ever any conflict between quality and meeting production goals and shipments

31. What are the companies standards for appearance i.e. all plaids must match, flat smooth seams, neat and accurate top stitching

32. Do you use statistical process control or any in process control of quality. For example do you use control charts or other tools that monitor quality levels over time. Or do you use flow charts to learn more about the manufacturing process. if yes please explain
Introduction of Research Project for Personal Interviews


Dear Participant:

I am a graduate student from the Textiles and Clothing Department at Iowa State University in Ames, Iowa. I am conducting a research project to learn about current quality assurance in industry, and to compare industry practices with the content of quality assurance classes in universities. I have selected you for an interview because of your involvement in your company's quality program and your expertise in this area. I would like to talk to you about the quality practices in your firm. Your participation will greatly contribute to my study.

I have prepared a list of topics to guide our discussion, so I may be taking some notes when I visit you at your company. If you have any questions throughout the duration of our discussion please feel free to ask them at any time. If there are any questions that you do not wish to answer, let me know and I will move onto the next question. The interview should take approximately forty-five minutes. All records of information that you share with me will be identified by number only. No names will appear on any information from you. Any further reporting of this research will be written without using names, companies, or cities. In order to be accurate I would like to tape record the interview. The only person other than myself who will hear the tape may be my thesis advisor.

Your participation in this study is voluntary. If you cannot participate I will understand. You may withdraw at any time. If you would like, I would be pleased to send you a copy of the results when my study has been completed.

Sincerely
Sandra F Chisholm (address, telephone, and Email address.)
8. Modified informed consent

1. Employees will be asked to participate in an interview. An interview guide will be used which includes the topics that I wish to cover. The interviewees will be informed that this is part of my masters thesis, and that I intend to compare quality practices in industry to those taught in academia.

2. The only discomforts felt by the interviewees may be if they felt uncomfortable providing any information which they think may be confidential. If this situation arises, the interviewee will be informed that they need not answer the question and the interviewer will move on to the next question.

3. The subject will be given the opportunity to receive a copy of the study results.

4. The only alternative would be for the subject to deny cooperation. They will be given this opportunity at any time.

5. The interviewee will be informed that they are free to ask questions at any time.

6. The subject will be informed that they are free to discontinue the interview at any time.

7. No names will appear on interview materials. There will be no direct link between names in the faculty study and information on who gave the information. Information regarding the name of firms will be coded.

8. The approximate length of each interview will be 30-45 minutes.
APPENDIX B: INTRODUCTORY LETTER TO COMPANIES
Dear contact name

I am a graduate student from the Textiles and Clothing Department at Iowa State University in Ames, Iowa. I am beginning my Master's thesis entitled: "Textile Quality Assurance: A Comparison Between Education and Industry." I want to explore current quality assurance practices in industry and compare the industry practices with those taught in quality assurance classes in colleges.

I intend to conduct multiple case studies of several apparel manufacturing firms in the Midwest. I am writing to you to ask if I can visit your company as part of my study. I would very much like to include Company name in my study because of the company's reputation for producing high quality products. I have chosen the companies that I am approaching for participation based on their product category, reputation, size, and price point. I am selecting companies to represent a diverse product range, and would be using company name as a representation of childrens apparel. No other companies that manufacture this category of product will be used in the study.

I anticipate that the case study will take two days to complete. I would like to use multiple sources of information including examination of quality-related documents such as any quality assurance manuals, personal interviews with quality personnel, and observations of manufacturing processes. Personal interviews would take approximately 30 minutes, and would consist of questions related to quality practices such as inspection, and the stages at which quality is addressed in the manufacturing process.

Participation in the study would be voluntary. Information would be kept confidential, and personnel being interviewed would remain anonymous. The company name would not appear on any report written about the research. I would be willing to share the results of the study with you and hope that you would benefit by learning what quality related skills prospective employees are gaining at educational institutions, and by changes that may be made to courses as a result of this study.

I will communicate with you again via telephone to answer any questions you may have. I plan to call on Tuesday February 28. Your participation would make a meaningful and important contribution to my study. Your cooperation is greatly appreciated. Thank you for your time.

Sincerely

Sandra F. Chisholm
(addresss and telephone number)
APPENDIX C: LETTER OF CONSENT
To whom it may concern,

I give permission to Sandra Chisholm, who is a graduate student at Iowa State University, to visit my company as part of her masters thesis entitled: "Textile Quality Assurance: A Comparison Between Education and Industry." I understand that participation in the study is voluntary, information will be kept confidential, and the company name will not appear on any report written about the research.

Signed______________________________

Title______________________________

Company____________________________
Dear March 1, 1995

I am a graduate student from the Textiles and Clothing department of Iowa State University in Ames, Iowa. Currently, I am beginning my Master's thesis entitled: "Textile Quality Assurance: A Comparison Between Education and Industry." My Thesis advisor is Dr. The purposes of my study are to explore current quality assurance practices in industry, identify the content of quality assurance classes in academia, and to compare the industry practices with those found in academia.

The industry study will consist of multiple case studies of several apparel manufacturing firms in the Midwest. I intend to use multiple sources of evidence including personal interviews with quality personnel, examination of documents related to quality, and observations of manufacturing processes.

In order to study the content of quality assurance/textile testing courses in academia, I am asking that faculty who teach such courses send me a current or recent syllabus, course objectives, description of assignments, and course catalog descriptions. In addition, I would like to know where else in the curriculum quality is addressed from a production perspective, and how quality is integrated across the curriculum. Additional syllabi and course descriptions may be sufficient to provide this information. Schools have been carefully selected to participate in the study based on information found in university catalogues, the reputation of the university, and knowledge of their program. Where possible, I have identified the faculty member who teaches the quality assurance/textile testing course. If my information is incorrect, please forward this letter to the appropriate faculty member.

I have enclose a postage paid return envelope for your convenience. All responses are voluntary and will be kept confidential. Your response will make a meaningful and important contribution to my study.

Your cooperation is greatly appreciated. Thank you for your time.

Sincerely

Sandra F. Chisholm
(address, telephone number, and email address)
APPENDIX E: HUMAN SUBJECTS APPROVAL
Information for Review of Research Involving Human Subjects
Iowa State University
(Please type and use the attached instructions for completing this form)

1. Title of Project: **Textile Quality Assurance: A Comparison Between Education and Industry**

2. I agree to provide the proper surveillance of this project to insure that the rights and welfare of the human subjects are protected. I will report any adverse reactions to the committee. Additions to or changes in research procedures after the project has been approved will be submitted to the committee for review. I agree to request renewal of approval for any project continuing more than one year.

   **Sandra F. Chisholm**  
   **Date:** 2/10/95

   **Type Name of Principal Investigator**

   **Department:** Textiles and Clothing  
   **Campus Address:** 1078 LeBaron Hall

   **Signature of Principal Investigator**

   **Campus Telephone:** 294-8519

3. Signatures of other investigators  

   **Date**  
   **Relationship to Principal Investigator**

   **Signature**

4. Principal Investigator(s) (check all that apply)  

   - ☐ Faculty  
   - ☐ Staff  
   - ☐ Graduate Student  
   - ☑ Undergraduate Student

5. Project (check all that apply)  

   - ☐ Research  
   - ☑ Thesis or dissertation  
   - ☐ Class project  
   - ☐ Independent Study (490, 590, Honors project)

6. Number of subjects (complete all that apply)  

   - 30 ☑ # Adults, non-students  
   - ☐ # ISU student  
   - ☐ # minors under 14  
   - ☐ # minors 14 - 17  

   **(Approx.)**

7. Brief description of proposed research involving human subjects: (See instructions, Item 7. Use an additional page if needed.)

   The purpose of the study is to explore current quality assurance practices in industry to identify apparel industry needs for undergraduate students, to identify the content of quality assurance classes in academia, and to compare the industry practices with those found in academia. The industry study will consist of four case studies of apparel manufacturing firms in the Midwest. The companies have been selected based on their size, product line, and price point. Within these firms I intend to conduct personal interviews of quality personnel to find out more about their quality practices. Interview subjects will be selected based on their job title and knowledge of the firms' quality operations, and likely will work closely with quality assurance. The subjects will likely be college age or above, and may be male or female. They will be asked questions regarding quality practices and programs established in the company. An interview schedule will be used to assist the interviewer. In order to study the content of quality assurance college courses, I will write (Please do not send research, thesis, or dissertation proposals.)

8. Informed Consent:  

   - ☐ Signed informed consent will be obtained. (Attach a copy of your form.)  
   - ☑ Modified informed consent will be obtained. (See instructions, item 8.)  
   - ☐ Not applicable to this project.
9. Confidentiality of Data: Describe below the methods to be used to ensure the confidentiality of data obtained. (See instructions, item 9.)

The interviewees will remain anonymous in that there will be no names on data collection forms and no link between information received and the individual who gave it. A number code will be given to each interview, but no record of the interviewee's name will be kept. The information received and the company who provided the information will be kept separately, only identified by a code. The information will be destroyed one year after the completion of this study - August 1996. Once the information has been received from faculty I will code the data and keep any identification of who sent it in a separate file. This information will also be destroyed one year after completion of the study - August 1996.

10. What risks or discomfort will be part of the study? Will subjects in the research be placed at risk or incur discomfort? Describe any risks to the subjects and precautions that will be taken to minimize them. (The concept of risk goes beyond physical risk and includes risks to subjects' dignity and self-respect as well as psychological or emotional risk. See instructions, item 10.)

The subjects may feel that some information regarding quality practices or course content is confidential or proprietary, and therefore may be unsure about giving such information. They will not be forced or required to give this or any other information. They will be informed that participation in the study is entirely voluntary and that they have the choice to discontinue their participation at any time.

11. CHECK ALL of the following that apply to your research:

- A. Medical clearance necessary before subjects can participate
- B. Samples (Blood, tissue, etc.) from subjects
- C. Administration of substances (foods, drugs, etc.) to subjects
- D. Physical exercise or conditioning for subjects
- E. Deception of subjects
- F. Subjects under 14 years of age and/or Subjects 14 - 17 years of age
- G. Subjects in institutions (nursing homes, prisons, etc.)
- H. Research must be approved by another institution or agency (Attach letters of approval)

If you checked any of the items in 11, please complete the following in the space below (include any attachments):

Items A - D Describe the procedures and note the safety precautions being taken.

Item E Describe how subjects will be deceived; justify the deception; indicate the debriefing procedure, including the timing and information to be presented to subjects.

Item F For subjects under the age of 14, indicate how informed consent from parents or legally authorized representatives as well as from subjects will be obtained.

Items G & H Specify the agency or institution that must approve the project. If subjects in any outside agency or institution are involved, approval must be obtained prior to beginning the research, and the letter of approval should be filed.
Checklist for Attachments and Time Schedule

The following are attached (please check):

12. [☐] Letter or written statement to subjects indicating clearly:
   a) purpose of the research
   b) the use of any identifier codes (names, #s), how they will be used, and when they will be removed (see Item 17)
   c) an estimate of time needed for participation in the research and the place
   d) if applicable, location of the research activity
   e) how you will ensure confidentiality
   f) in a longitudinal study, note when and how you will contact subjects later
   g) participation is voluntary; nonparticipation will not affect evaluations of the subject

13. [☐] Consent form (if applicable)

14. [☐] Letter of approval for research from cooperating organizations or institutions (if applicable)

15. [☐] Data-gathering instruments

16. Anticipated dates for contact with subjects:
   
<table>
<thead>
<tr>
<th>First Contact</th>
<th>Last Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/13/95</td>
<td>04/13/95</td>
</tr>
<tr>
<td>Month/Day/Year</td>
<td>Month/Day/Year</td>
</tr>
</tbody>
</table>

17. If applicable: anticipated date that identifiers will be removed from completed survey instruments and/or audio or visual tapes will be erased:
   
   August 31 1996
   
   Month/Day/Year

18. Signature of Departmental Executive Officer    Date    Department or Administrative Unit
   
   [Signature]
   
   3/22/95            TEXTILES + CLOTHING

19. Decision of the University Human Subjects Review Committee:
   
   ☑ Project Approved    ☐ Project Not Approved    ☐ No Action Required
   
   Patricia M. Keith
   
   Name of Committee Chairperson    Date    Signature of Committee Chairperson
   
   3/22/95

SC: 1/90