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The Pennsylvania State University
The Graduate School
Department of Civil Engineering

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AN ANALYSIS OF QUALITY
IN THE MODULAR HOUSING INDUSTRY

A Report in
Civil Engineering
by
Derwood J. Mason III

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Engineering
December 1991



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PREFACE

For the past several years, the United States Navy Civil Engineer Corps has placed a strong emphasis on quality management in all of its operations. The current name for this program is Total Quality Leadership. This program sets the Corp's primary goal as ensuring the satisfaction of its customers. This report examines the quality management principles that the Total Quality Leadership Program is based on (Chapter 2), and uses them to analyze the current state of quality in the modular housing industry.

The U.S. Navy has purchased modular homes in the past, and will most likely continue to do so. This report analyzes the quality advantages and disadvantages offered by modular housing, and provides a quality management rating scale (Chapter 4) that can be used to rate the quality management programs of modular home manufacturers that are prospective suppliers of Navy Housing. The report also provides a survey (Chapter 5) which can be used to measure the level of consumer satisfaction with the quality of their modular homes. These tools can be modified and used to analyze the quality of stick-built homes and the quality management programs of stick-builders as well.

ABSTRACT

Although the modular housing industry has been increasing its share of the U.S. housing industry, modular housing has not been widely accepted by the American consumer as an attractive housing alternative. One of the possible reasons for this lack of widespread acceptance is that the typical American consumer perceives modular housing as a low quality, and therefore, undesirable product. The modular housing industry faces the formidable task, therefore, of eradicating this stigma in order to gain wider acceptance of modular housing as a viable quality housing alternative.

This report provides an assessment of the current state of quality within the modular housing industry. The quality management practices of three modular manufacturers are analyzed and compared with an "ideal" quality management plan. The degree to which the three manufacturers are meeting and exceeding their customers' needs is also analyzed. Several of the quality advantages and disadvantages offered by modular homes are also identified in this report. The methodology used can be adapted by individual systems built housing manufacturers to assess and improve their quality management efforts and the quality of their products.

25 * House (2nd floor) * Main
* Index

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CHAPTER 1

INTRODUCTION

1.1 DEFINITION OF MODULAR HOMES

The evolution of the systems built housing industry has led to several distinct types of manufactured homes. These include panelized homes, modular homes, log homes, and geodesic dome homes. This report deals strictly with modular homes, which are defined as residential structures built or erected from two or more factory finished three-dimensional cubical or box-shaped units which are set on permanent foundations, connected together and finished in the field [1]. The modular manufacturing process is explained in Figure 3.1 in Chapter 3. Setting and field finishing are typically completed by a builder/dealer (hereinafter referred to as the builder), who purchases the home modules from the manufacturer. The consumer buys the completed home, ready for move-in, from the builder.

These units, or "modules" as they are commonly called, are typically 12 to 14 feet wide, 24 to 66 feet in length, and 90-95% completed (including electrical, plumbing, appliances, fixtures, windows, doors, and finish work) when they leave the factory.

Field finishing typically consists of setting and connecting the modules, connecting site utilities, and completing the plumbing, electrical, mechanical, and finish systems.

Although often confused with mobile homes, modular homes differ from mobile homes in that they are built to comply with the conventional building codes in the United States (i.e. Building Officials and Code Administration International [BOCA], International Conference of Building Officials [ICBO], Southern Building Code Congress International [SBCC], National Electric Code [NEC], National Fire Protection Association [NFPA], Council of American Building Officials [CABO], and various other state and local codes). Mobile homes, on the other hand, are built to meet the Federal Manufactured Housing Construction and Safety Standards act (HUD Code). Modular homes are essentially stick-built homes that are primarily built in the factory rather than in the field.

1.2 MODULAR HOME MARKET TRENDS

Modular homes were originally intended to provide the American consumer with an affordable housing alternative [2]. However, since the boom years of the mid 1980's, the majority of the modular housing industry has followed the rest of the residential construction industry in increasing its emphasis on custom and move-up homes.

Residential modular market share relative to total housing permits was about 2% nationally in 1988, and is expected to grow to 3.3% by 1994 [3]. Residential modular production is concentrated geographically, with about 75% of the total consumption occurring along the East Coast [3]. The Northeastern states increased their consumption of modular homes from about 30% of total national modular consumption to greater than 50% of total consumption during the mid 1980's, with New York state emerging as the leading consumer and Pennsylvania as the leading producer of modular homes [3].

Residential modular production is also highly concentrated among a small number of manufacturers.

1.3 PROBLEM STATEMENT

Although the modular housing industry has been increasing its share of the U.S. housing industry, modular housing has not been widely accepted by the American consumer as an attractive housing alternative. One of the main reasons for this lack of widespread acceptance is that the typical American consumer perceives modular housing as a low quality, and therefore undesirable product [4]. Although no research has been conducted to establish why this stigma has been attached to modular housing, it can be theorized that American consumers automatically associate the term "modular housing" with mobile

homes [1]. Additionally, it is possible that American consumers are not aware of the modular industry's move toward custom and move-up homes, and therefore still erroneously associate modular housing with "affordable" or low quality homes. Regardless of the origin of this stigma, it is real and must be eradicated before modular housing can be widely accepted by American consumers as a viable quality housing alternative.

The modular housing industry faces a formidable task as it attempts to eradicate this stigma. One of the ways that this can be accomplished is through wide-scale marketing efforts designed to educate American consumers about the quality advantages of modular housing.

1.4 OBJECTIVE OF THIS REPORT

Prior to undertaking a marketing effort to educate American consumers about the quality advantages of modular housing, the advantages must first be clearly identified. The primary objective of this report, therefore, is to identify several of these quality advantages. Additionally, this report investigates the following assertions about the quality of modular housing:

1. The controlled environment of a modular housing plant provides the optimum setting for controlling product quality.
2. Modular housing manufacturers are taking advantage of this

optimum setting by employing modern quality management practices to rigidly control the quality of their product.

3. Builders and consumers are highly satisfied with the quality of the modular homes they receive from manufacturers.

Substantiation of these three assertions would provide manufacturers with a sound base upon which marketing claims about the quality advantages of modular housing could be founded.

1.5 SCOPE

The research effort described in this report must be viewed as an introductory analysis of the quality issue in the modular housing industry, because of funding and time restrictions. The study concentrated on three separate modular home manufacturers in an attempt to identify the quality advantages of modular homes, and to support the three assertions listed in the previous section. It should be noted that the methodology used in this report can also be used by an individual manufacturer to identify the quality advantages of its product, or it can be expanded for use on a wider scale (regional or national).

1.6 METHODOLOGY OF THE STUDY

The following research steps were taken to meet the

objectives of this report: 1. a literature review was conducted; 2. an ideal quality management plan was developed; 3. in-plant quality reviews were conducted; 4. builder and consumer surveys were circulated; 5. The data was analyzed.

An extensive literature review was conducted in the areas of: (1) modern quality management concepts and (2) modular housing. The quality management review provided the writer with a sound understanding of modern quality management practices and principles. It is imperative that anyone attempting to perform a similar study become familiar with these practices and principles (see the List of References at the end of this report).

The modular housing literature review provided the writer with an understanding of the current state of information about the modular housing industry. No detailed information was found that addressed the application of modern quality management procedures in the modular housing industry.

The Ideal Quality Management Plan was developed by consolidating the modern quality management practices and concepts derived from the literature search and tailoring them to fit the modular housing process. The ideal plan was then used to evaluate the degree to which modular housing manufacturers are employing modern quality management techniques.

In-Plant Quality Reviews were conducted in three modular manufacturing plants in order to:

- Identify the quality advantages of modular homes.

- Determine whether the controlled environment of a modular housing plant provides the optimum setting for controlling product quality.
- Determine the degree of modern quality management techniques being used by manufacturers in the industry.

The Builder and Consumer Survey was conducted by developing a questionnaire which was distributed to builders and consumers (home buyers) of the three manufacturers in order to: (1) measure their degree of satisfaction with the quality of the manufacturers' homes, and (2) to establish a builder/consumer definition of quality as it applies to modular homes.

The results of the surveys and plant assessments were then analyzed and incorporated into the body of this report.

1.7 ORGANIZATION OF THIS REPORT

This first chapter has briefly defined the modular housing industry and the challenge that it faces in changing the perception which American consumers have that modular housing is a low-quality, undesirable housing alternative. The objectives, methodology, and organization of the report were also presented in this chapter.

Chapter 2 analyzes the basic elements of modern quality management, and provides a brief history of the evolution of modern quality management concepts and practices.

Chapter 3 presents a simple model of a typical modular home manufacturing plant and analyzes why this type of environment is, and sometimes is not, an ideal setting for controlling product quality.

Chapter 4 assesses the degree to which the three participating manufacturers are employing modern quality management techniques.

Chapter 5 analyzes the level of builder and consumer satisfaction with the homes produced by the participating manufacturers, and provides builder and consumer definitions of quality in modular homes.

Chapter 6 identifies the quality advantages of modular homes.

Chapter 7 provides some general conclusions and recommendations, and defines several suggestions for further research.

CHAPTER 2

IDEAL QUALITY MANAGEMENT

2.1 INTRODUCTION

There are several important elements that should be included in an ideal quality management plan. This chapter discusses each of these elements in detail, and provides a brief history of the evolution of modern quality management concepts and practices.

2.2 TERMINOLOGY

Quality is a difficult topic to deal with since people attach different meanings to the word. In order to effectively discuss the concepts of quality and quality management, one should first define the terminology commonly used. Many different writers (and many companies for that matter) have established their own definitions of the common quality-oriented terms. Based upon a literature review, the writer has compiled a

list of definitions, some of which are explained in this chapter, others appear in Appendix A. These definitions are not absolute. The reader will encounter others in quality related discussions and articles.

2.3 DEFINITION OF QUALITY

A common problem in many companies is that their definition of quality is vague and general, rather than specific [5]. Such companies may define quality as "goodness," or "luxury," or "fitness for use." The problem with such definitions is that there is no way to measure or control quality when it is thought of in such vague terms.

A suitable definition of quality is one which is based on tangible aspects and allows measurement of the quality of products. Table 2.1 presents definitions provided by several quality "experts." These definitions were consolidated by the writer to form the definition of quality as it will be used in this report. Quality includes each of the following aspects:

- Freedom from defects.
- Meeting specifications and standards as set by the consumer, the industry, and the company.
- Meeting consumer expectations and needs.
- Exceeding consumer expectations and needs.
- Affordability and competitive price.

TABLE 2.1 - DEFINITIONS OF QUALITY

AUTHOR	DEFINITION
1.) Philip B. Crosby	Conformance to requirements [5].
2.) W. Edwards Deming	Meeting present and future needs of customers [6].
3.) J.M. Juran	Those product features that respond to customers' needs; freedom from deficiencies [7].
4.) Joseph R. Tunner	Satisfying customer needs and exceeding customer expectations consistently and efficiently [8].

Accordingly, the definition of quality that will be used in this report is:

Consistently meeting and exceeding consumer needs
and expectations at an affordable price, with no defects
over the life of the product.

This definition of quality allows each of the elements comprising quality to be quantitatively measured and controlled.

2.4 IMPORTANCE OF THE CONSUMER

It is necessary to highlight two extremely important aspects of this definition of quality. The first is that the consumer should be the root focus of any company's quality management

effort. The goal of any company is to produce a product that consumers will consistently want to buy. A quality oriented company will therefore know and understand consumer expectations and needs, and ensure that all research, marketing, design, manufacturing, and service efforts are based on these expectations and needs. Every individual within a company must be familiar with consumer expectations and needs, and must realize how the role that they perform within the company contributes to meeting them.

The second important aspect of quality that must be highlighted is the goal of exceeding consumer expectations and needs[6]. A company that is able to consistently exceed consumer expectations and needs will consistently find itself with highly satisfied customers, and satisfied customers lead to market acceptance and consumer advocacy of a product. It is therefore extremely important for a company to focus its attention on ways of exceeding consumer expectations and needs.

2.5 BRIEF HISTORY OF QUALITY TRENDS

Before discussing the current concepts of ideal quality management, the historical concepts of their evolution should be understood. In the late nineteenth century, American industry adopted the Taylor System of "scientific management" [7] which required workers to follow specifications set forth by

specialists [9]. From this concept emerged the definition of quality as "conformance with specifications." This is an important element of modern definitions of quality, but is no longer accepted as being all inclusive.

In the 1920's, factory managers adopted a new strategy of creating central inspection departments [7], whose primary role was to detect product defects. According to modern quality management theory, this development had a negative impact on the quality of American manufactured goods, since it fostered the notion in the minds of American workers and industry managers that defects were "normal."

The next evolutionary step was the creation of a quality department within a manufacturing organization. The typical focus of the quality department was inspection and testing, that is, separating good product from bad. The positive aspect of this development was that it helped prevent defective products from reaching the consumer. However, it did nothing to erase the mindset that defects are normal, while also instilling the misconception that quality was solely the responsibility of the quality department [7].

Until the 1970's, the evolution of quality management in the United States did not progress much beyond this point. In the meantime, an interesting movement developed in Japan.

2.5.1 The Japanese Headstart

After World War II, the Japanese embarked on a course of reaching national goals by trade rather than by military means [7]. At this point in time, Japanese manufactured goods had the international reputation of being shoddy products. To overcome this problem, the Japanese dedicated themselves to learning how other countries managed quality. Their dedication to quality improvement resulted in the following revolutionary strategies for creating products of unprecedented quality [7]:

1. Upper managers had to become personally involved in quality management.
2. All levels and functions of management underwent training in managing for quality.
3. Quality improvement measures were undertaken at an incredible pace.
4. The work force became personally involved in quality improvement.

By the mid 1970's, Japanese product quality surpassed that of western countries (see Figure 2.1). American companies, who had previously believed that Japanese products outsold American products because of cheaper prices due to cheaper labor, now began to focus once again on the importance of quality management. These American companies received additional impetus from growing public awareness of the role of quality, and the

emergence of consumer organizations that promoted better quality.

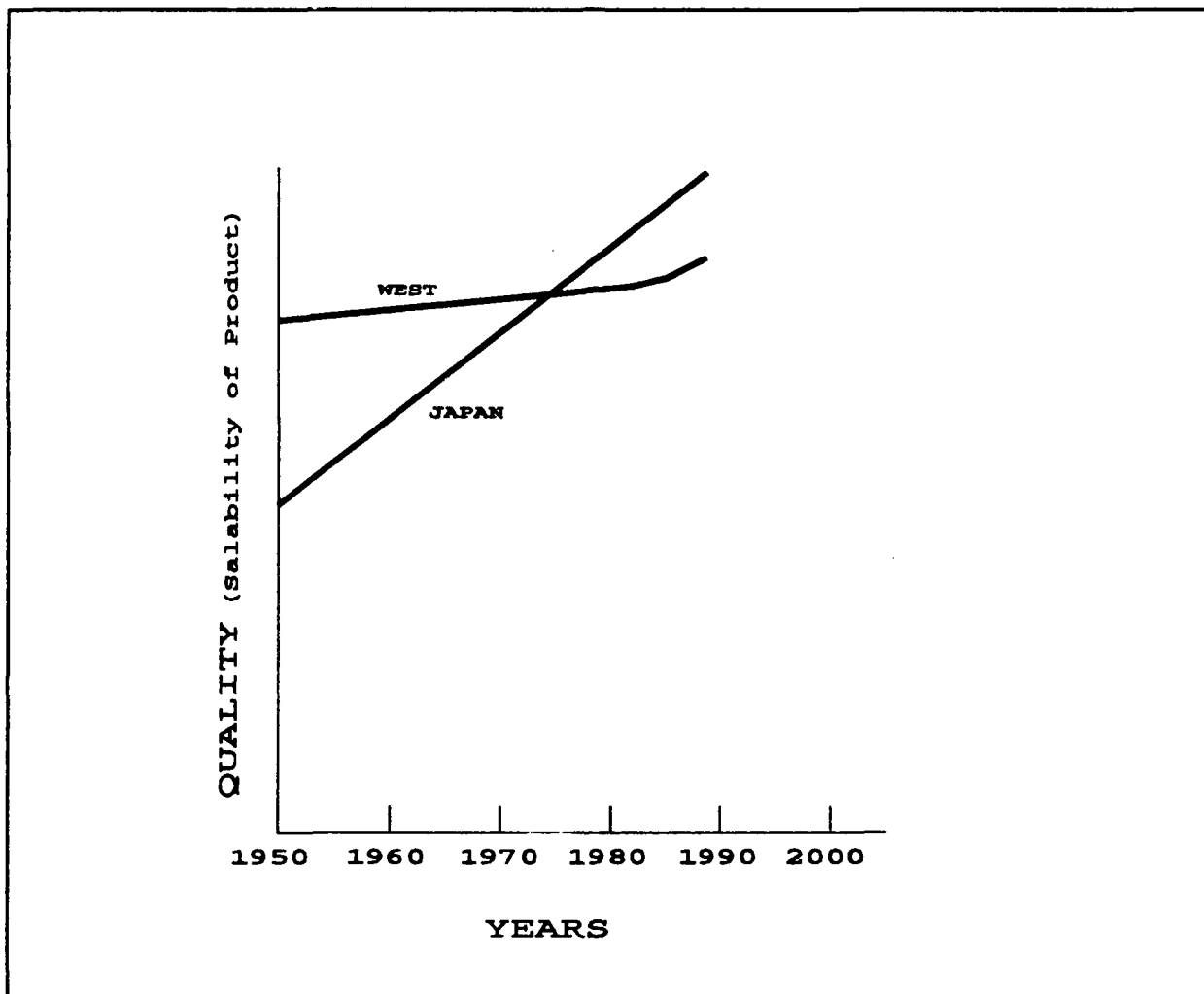


FIGURE 2.1 - JAPANESE vs. WESTERN QUALITY (Source: [7])

Currently, the United States is witnessing a trend of increased emphasis on improving the quality of American manufactured goods. American companies such as Ford and ITT are now incorporating modern quality management concepts into their management strategies.

Several misconceptions, still widely held in the U.S., have

TABLE 2.2 - MISCONCEPTIONS OF QUALITY

<u>MISCONCEPTION</u>	<u>ACTUAL TRUTH</u>
1.) Poor quality is a worker problem.	1.) 75% to 85% of the responsibility for defects lies with management [9].
2.) Quality is solely the responsibility of the quality department[5].	2.) Every individual within a company is responsible for quality [9].
3.) Defects are normal and acceptable.	3.) Defects should not be considered normal and acceptable. Company should focus on correcting the root causes of defects [6].
4.) Quality goods are much more expensive to produce.	4.) Improving the quality of goods via sound quality management techniques can reduce the cost of products by 5% to 10% of sales. It is always cheaper to do the job right the first time [5].
5.) Quality is intangible and cannot be measured.	5.) Quality, if defined properly, can be easily measured [5].
6.) People do not care about doing good work.	6.) If there are no barriers to doing good work, people will strive to do good work [6].

impeded a wider acceptance of the goal of improving and modernizing quality management systems. These misconceptions, and the actual truth about each, which are listed in Table 2.2, must be overcome before a firm can successfully implement modern quality management techniques within its organization.

2.6 BASIC ELEMENTS OF MODERN QUALITY MANAGEMENT

Although the Japanese did develop several new quality concepts on their own, many of the basic quality management concepts that they now use were actually derived from ideas previously established by American quality "experts" such as W. Edwards Deming and J.M. Juran. Table 2.3 lists these basic

TABLE 2.3 - BASIC ELEMENTS OF MODERN QUALITY MANAGEMENT

- 1) The Role of Management
 - 2) The Quality Policy
 - 3) The Role of the Worker
 - 4) Designing for Quality
 - 5) The Role of the Sales and Marketing Department
 - 6) Quality of Materials
 - 7) Quality of the Manufacturing Process
 - 8) The Need for Constant Improvement
 - 9) Feedback Loops
 - 10) Training
 - 11) Quality Audits
 - 12) Quality Control
 - 13) The Role of the Quality Department
 - 14) The Costs of Poor Quality
-

elements of modern quality management, which can be adapted and tailored to fit any type of manufacturing process or service organization. The remainder of this chapter describes each of these basic elements in detail.

2.6.1 The Role of Management

Management commitment to quality is absolutely essential. Without upper management commitment to quality, there is no possibility of having a quality-focused organization [8]. Management must also have a thorough understanding of quality management concepts. Management must actively participate in all aspects of quality management, and must not expect the quality department to perform the entire role of quality management.

Many companies presently focus their primary attention on short-term profits, and within these companies, managers are commonly evaluated on their ability to generate them. Upper management must understand that a good, sound quality management program can take 7 - 10 years [5] to fully establish and implement, and must ensure that the company's focus is on long-term profit and reputation for quality.

Management should establish standard definitions in order to avoid confusion about the company's quality policy and goals. Management should also develop the company's quality policy and then actively support it.

Management must ensure that the company's entire quality management system is based upon meeting the needs and expectations of its consumers, and that all employees realize that "Consumer is King" [9]. It is important for management to foster a team approach to quality management [8], and ensure that every worker within the company understands his or her role in the quality system and actively participates in ensuring product quality. Management must also provide subordinates with the proper training, tools, equipment, and resources for consistently producing quality products.

Management must clearly understand human error and the natural variability of manufacturing processes [7] and make sure that blame is not placed on individuals. Management should also solicit and then seriously consider all worker suggestions. Management should actively participate in quality audits, establishing a quality control manual, and developing training programs.

In summary, it may be stated that management must perform the critical role of actively leading and supporting the company-wide quality effort and must ensure that the necessary resources for producing top quality products are made readily available to every individual within the company.

2.6.2 The Quality Policy

A true quality-oriented company must establish a clear, concise policy about quality that is fully supported by management and believed in and adhered to by all company employees. Without a clear-cut quality policy, a company's approach to quality is likely to very inconsistent [8]. This policy should focus on long-term company goals and values and insist that short term actions be consistent with these values. A quality policy is different from a quality control plan in that it does not address the details of the role of each employee's individual responsibility in controlling product quality within the manufacturing process. Rather, it delineates the global quality issues and broadly delineates the responsibilities that every member of a company must assume.

2.6.3 The Role of the Worker

Before discussing the role of the worker, it is important to note that workers cannot perform beyond the limits of the tools, equipment, resources and training provided to them. In other words, it is management's responsibility to ensure that workers are equipped to perform in the manner described in this section. A company that is truly committed to consistently producing high quality goods must realize that its workers are its most

important asset [6].

The most important responsibility of every worker within a quality-oriented organization is to clearly understand that his or her goal must be to meet and exceed the needs and expectations of the consumer. The ability of the product to meet this goal should be built-in via proper design, but each individual within a company must still realize his or her contribution in satisfying the consumer.

The consumer, or end-user of the product, may also be referred to as the customer. The term "customer" in a quality-oriented company does not, however, always refer to the consumer. In a quality-oriented company, the "customer" also refers to the next person or work station down-line from the person or work station being considered. For example, the immediate customer of the wall framing crew in a modular housing plant is the wall setting crew which must use its "product". It is thus the responsibility of every individual within a quality-oriented company to understand the needs and expectations of his or her immediate customers (or next station down-line) as well as the final consumer of the product. J.M. Juran has referred to this concept as the TRIPROL [7] responsibility of workers, whereas each individual within an organization plays the triple role of customer, processor, and supplier. Every individual within a company must understand and support this concept in order for quality products to be consistently manufactured.

It is also extremely important for each worker to receive proper and adequate training in: (1) the skills that are needed to perform his or her role; (2) the quality policy of the company; (3) the needs of immediate customers as well as consumers; and (4) the overall production process of the company.

Modern quality management theory also promotes the idea that workers should be trained well enough to make decisions about whether or not the product, as it leaves his or her station, conforms with quality requirements [7]. It is believed that this type of quality control actively involves the worker in monitoring the quality of products, and thus develops within each individual a sense of ownership in the product. This concept also keeps workers tuned in to the needs of their immediate customers, and thus fosters a team approach to ensuring quality products. Additionally, with this arrangement, it is easier to identify the root causes of product defects, since each individual actively participates in and understands the quality control process. Quality control inspectors should still perform their role, but more within the context of "quality assurance" since workers actually perform the quality control function themselves.

Workers must also feel free to communicate their ideas, suggestions, and problems to their superiors. Workers know better than anyone what is wrong with the process or what could make the process easier (thereby saving money). Supervisors and

managers should sincerely accept and act upon the ideas, comments and suggestions of the workers in order for the workers to believe that their superiors do care about their ideas. This will open up lines of communication throughout the company, which is an essential aspect of a sound quality management system.

Workers should also provide input into the design process. Workers are the best source of information about how to design a product for ease of manufacture. Ignoring worker input is the same as ignoring cost-saving opportunities.

2.6.4 Designing for Quality

The design process is very important in producing high quality products. The first criteria for designing a quality product is to ensure that all elements of the product meet consumer needs and expectations. It is therefore imperative that the design department be intimately familiar with these needs and expectations, so that they can be incorporated into the design. Accordingly, the design department must work very closely with the sales and marketing department in order to clearly understand consumer needs and expectations.

In addition to ensuring that consumer needs and expectations are designed into the product, the design department plays the very important role of ensuring the ease of manufacture of the product. This aspect of quality design is critical because

complicated designs lead to complicated manufacturing processes, which open the door to a high probability of defects. This aspect is also critical since a considerable amount of cost savings can be recognized by ensuring ease of manufacture. Quality designs also concentrate on eliminating waste material and scrap which leads to further cost savings.

A high quality design will also ensure that good quality materials are specified and that production drawings are clear, easily understood, and free of defects. Internal and external requirements and standards must also be incorporated into the design. The design department must also ensure that the design contains a certain element or elements that will exceed consumer needs and expectations.

2.6.5 The Role of the Sales & Marketing Department

The sales and marketing department is the critical link between the company and the consumer. This department, better than any other, should clearly understand the needs and expectations of the consumer, and should constantly strive to stay attuned to these needs and expectations. If this department is functioning correctly, it will be the company's source of ideas on ways to exceed consumer expectations and needs. This department must ensure that the information it collects about consumer needs and expectations is made readily available to the

rest of the company and that the company is continually updated to keep abreast of these changing needs and expectations.

The sales and marketing department should also actively pursue consumer feedback. This is a critical element of any quality management system because it is an effective way of measuring whether or not the company is meeting and exceeding consumer needs and expectations.

2.6.6 Quality of Materials

A quality-oriented company will ensure that it uses quality materials. Quality materials are defined in the same manner as quality products. Quality materials meet and exceed the needs and expectations of the company and the consumer, are free of defects, are produced in accordance with company, industry, and consumer standards and specifications, and are sold at a price that is affordable to the company.

A quality-oriented company does not make the mistake of purchasing materials based upon price alone [6]. Instead, it selects suppliers based on the consistency and quality of their materials and the degree to which the suppliers understand and meet the needs and expectations of the company.

Ideally, a company will limit itself to only one completely reliable supplier for each type of material it needs [9]. This greatly reduces the variability of materials and adds to the

consistency of the manufacturing process. After selecting a supplier, a quality-oriented company will train and educate the supplier about the company's quality policy and quality system, ultimately making all suppliers part of the team effort towards ensuring quality. Such a pro-active stance also eliminates the need for (and expense of) vigorous inspection of incoming materials [6].

2.6.7 Quality of the Manufacturing Process

A quality-oriented company makes sure efficiency is built into its manufacturing process. That is, the manufacturing process is designed to consistently deliver what is required without generating scrap or rework, and without relying on massive checks and inspections to find discrepancies before they are found by consumers [8]. Essentially, the ideal manufacturing process is designed to ensure that the job is done right the first time [5]. A process designed in this manner will minimize the unnecessary costs that must ultimately be passed on to the consumer.

A quality manufacturing process employs tools and equipment that are designed to allow the work to be performed in the most efficient manner possible. These same tools and equipment should be of sufficiently high quality themselves in order to minimize breakdowns, failures, and maintenance expenditures.

A quality process is also designed to allow easy detection and correction of sources of deficiencies. Its central focus should be on quality and conformance, and not on numerical production goals [9] which center the entire company's attention on quantity rather than quality.

2.6.8 Need for Constant Improvement

A perfect quality-oriented company would perform every step of its manufacturing process, from design to sales, correctly the first time - every time. All waste, scrap and rework would be totally eliminated, and the efficiency of every step of the process would be completely maximized. Obviously very few, if any, companies have ever achieved this level of proficiency in quality management, and thus there is always room for improvement.

A quality-oriented company will constantly study every step of its process, and every element of its quality management system, continually looking for areas of possible improvement. In order for constant improvement to become a reality, a company must ensure that employees at all levels are dedicated to finding ways of improving the system [8]. Improvement of processes leads to less rework and inspection, and thus to a higher quality product at a lower cost [6].

2.6.9 Feedback Loops

In order for a good quality management system to function properly, there must be open feedback occurring at all levels within a company and between the company and its suppliers and consumers. Without feedback, discrepancies will never be traced to their root source and eliminated, the company will not know if it is satisfying its customers, and a team approach to ensuring quality products will not exist.

In an ideal quality management system, discrepancies are discovered and traced to their root cause. The production process is then modified to eliminate the root cause of the discrepancy, thus forever eliminating this type of discrepancy from the process (this is one aspect of continuous improvement). Without proper feedback loops in place, discrepancies are detected and corrected but the root cause of the discrepancy remains in place and future discrepancies of the same nature are inevitable.

A quality-oriented company must actively solicit feedback from its consumers via surveys, or it will never know if it is meeting the needs and expectations of consumers. Feedback loops must also exist between departments, between workstations, and between management and subordinates in order for a company to approach quality as a team at all levels.

2.6.10 Training

It is the role of upper management and the quality department to design a training curriculum that will educate all employees of a company about quality concepts and the quality policy and goals of the company. Management must attend the first training sessions that are held [7] in order to develop an early understanding that will allow them to lead the company's growth in quality. Management must realize that training is necessary at all levels of all departments - not just in the quality department.

In addition to conveying information about quality concepts and the quality policy and goals of the company, a company's training curriculum should also include: (1) training for specific job tasks, (2) an understanding of the overall manufacturing process, and (3) the procedures for instituting the team approach to quality management [6]. Training should be a continuous process and should be held on a regular basis.

Effective training will result in employees who understand and actively and willingly participate in the company's quality management system. Workers will also take greater pride in their work and feel more secure in their jobs since they have become involved in a process that encourages open feedback and communication with their superiors [6]. A quality-oriented company will value its well trained workers and will strive to

retain those workers who are intimately familiar with what it takes to produce quality goods.

2.6.11 Quality Audits

A quality-oriented company will regularly perform quality audits. A quality audit is a diagnosis of the overall state of the quality management efforts of a company [9]. A thorough quality audit will check the status of each of the basis elements of modern quality management listed in this chapter.

The reasons for performing quality audits are [8]:

1. To update the quality system.
2. To demonstrate company commitment to quality.
3. To identify areas having unusual strengths.
4. To identify weaker areas that are in need of improvement.
5. To track the progress of quality improvement efforts.
6. To satisfy requirements from outside the organization.

A quality-oriented company realizes that these in-house quality audits have the single overriding purpose of helping the entire organization get better [8]. Quality audits are not contests to separate poor performers from good performers and a company must therefore ensure that audits are not used to compare different areas of the company to one another. Quality audit findings should never be used in a punitive way. Employees should not fear quality audits and they should consider them to

be a part of the normal routine of improving the overall quality system of the company.

The list of individuals to be included on the audit team, depends upon a number of company and process factors. In an ideal quality management system, everyone within the company should at some point in time participate as a member of a quality audit team. This approach fosters teamwork in the quality effort as well as a company-wide understanding of the quality management system. Top executives, department managers, supervisors, employees, and quality department personnel should all be part of quality audit teams.

It is imperative that the company's feedback loop be used to follow up on audit findings. Every individual and department that even remotely contributes to or receives the results of positive or negative audit findings must be aware of the findings and participate in problem-solving and recognition of good performance.

Quality audits can be the keystone of a top-notch quality management system, or they can be a total waste of time [8]. If audits are done in a timely professional manner, in a positive spirit, and with conscientious follow-up, they will be invaluable in driving a company toward excellence.

2.6.12 Quality Control

As previously discussed in the *Designing for Quality and Quality of Manufacturing Process* sections of this chapter, quality (and every aspect of its definition) should be built into the design of a product. The manufacturing process should be designed to ensure that the product is consistently and efficiently manufactured with high quality and no defects. It was also previously stated that since there are no "perfect" quality management systems in existence, there is always room for improvement.

This is where quality control fits into the quality management system. Quality control includes the detection and elimination of defects within the manufacturing process and the elimination of them at their root causes so that they will not be repeated. The typical quality control cycle for a modern quality-oriented company is shown in Figure 2.2.

There is a subtle, but extremely critical difference between this modern approach to quality control and what is commonly practiced as quality control. The common approach to quality control detects defects and corrects them before they can reach the consumer, but does not eliminate the root cause of the defects. A company that is well-versed in modern quality management methods truly believes that defects should not be accepted as normal and realizes that eliminating the root causes

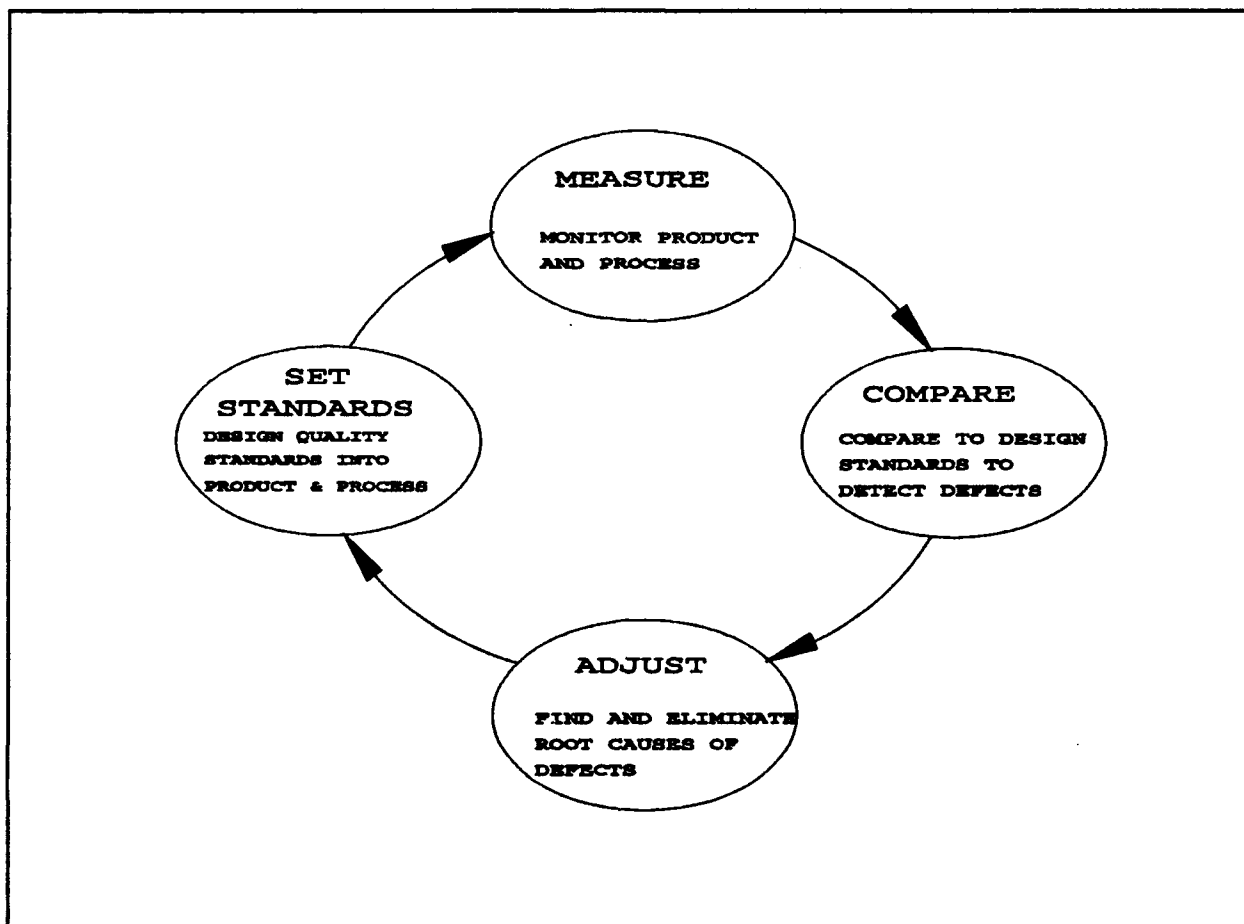


FIGURE 2.2 - TYPICAL MODERN QUALITY CONTROL CYCLE (Source: [7])
of defects ultimately eliminates unnecessary costs [5].

There are many modern statistical techniques that can be used in performing quality control, all of which are thoroughly discussed in some of the quality textbooks included in the List of References. This report, however, will restrict itself to a focus on inspection as the primary quality control technique.

As previously stated, inspections should be performed in order to compare products with design specifications and requirements, thus identifying defects in products. Products

should be inspected during the manufacturing process as well as at the end of the production line. This allows for detection of defects as early as possible within the manufacturing process. Inspection checklists should be derived directly from production drawings and specifications.

A modern quality-oriented company should have the goal of minimizing inspection costs. This goal can be attained by implementing two elements of modern quality management that were discussed previously. First, the company should train workers well enough to make conformance decisions on their own, thereby minimizing the cost of inspectors. Similarly, the company should constantly strive to improve the manufacturing process by eliminating the root causes of defects, thereby minimizing defects and the level of inspection that is required.

2.6.13 The Role of the Quality Department

A modern quality-oriented company does not believe in the common misconception that the sole role of the quality department is to perform quality control inspections. Modern quality-oriented companies clearly understand that the primary role of the quality department is to monitor, orchestrate, and update the company's overall quality management system.

Contrary to popular belief, the quality department must be an integral part of the manufacturing process and should not

play a "watchdog" role within the company [8]. A quality department that is regarded by workers as the police force of the company is not functioning in accordance with modern quality management theory. When a quality department is regarded in this manner, employees tend to resent and fear the quality department as a source of criticism. As a result, there are no open lines of communication within the company and there is no team approach to ensuring quality products. An employee's understanding of quality is limited to a negative association with the quality department.

A properly functioning quality department is regarded by the company as a source of knowledge about how to best ensure quality products. The quality department should assist management in planning and coordinating the company's: (1) training curriculum; (2) quality audits; (3) quality control inspections; and (4) quality policy, and should monitor the progress of quality improvement as well as the state of all of the basic elements of the company's quality management system. In addition, a highly effective quality department continually presents top management with status reports of the cost savings that result from the company's quality management efforts [5].

2.6.14 The Costs of Poor Quality

A quality-oriented firm realizes that the cost of poor

quality can be as much as 5% to 10% of sales [5]. It follows then that a quality-oriented company realizes that sound quality management can save the company as much as 5% - 10% of sales per year. Such a company also recognizes the fallacy of the common misconception that adding quality to products is "gold plating" or adding to the cost of products.

Thus far, this chapter has described the basic elements of modern quality management systems. It is through the implementation of all of these elements that cost savings of this magnitude can be realized. A quality-oriented company will ensure that a portion of these cost savings will reach the consumer, thus providing the consumer with a high quality product at an affordable price.

The most difficult problem faced by companies trying to realize these cost savings is in quantifying them. The actual costs will vary from company to company and it is the role of the quality department to work closely with the comptroller in identifying all of the costs of poor quality [5]. Once these costs have been identified, they can be used as an indicator which tracks the progress of the company's quality efforts in terms that top management can relate to - dollars. Table 2.4 provides a partial list of some of the common sources of the costs of poor quality. Each of these costs will diminish as a company's quality management effort becomes more and more effective through constant improvement.

TABLE 2.4 - COSTS OF POOR QUALITY (Source: [5])

PREVENTION COSTS

- design reviews
- product qualification
- drawing checking
- engineering quality orientation
- specification reviews
- tool control
- operation training
- quality audits
- preventive maintenance

APPRAISAL COSTS (costs of determining whether process and product meet requirements)

- prototype inspection and tests
- production specification conformance analysis
- supplier surveillance
- receiving inspections and tests
- product acceptance
- process control
- quality control inspections

FAILURE COSTS (costs of nonconformance)

- consumer affairs
- redesign
- engineering change order
- purchasing change order
- corrective action costs
- rework
- scrap
- warranty
- callbacks
- product liability

2.7 SUMMARY

This chapter has provided a brief history of the evolution of modern quality management principles and techniques, and a detailed description of the basic elements of ideal quality

management. These basic elements have been used to develop an ideal quality management plan outline which is listed in Appendix B. The next chapter examines the modular home manufacturing process and analyzes whether or not the process is conducive to effectively managing the quality of the product.

CHAPTER 3

QUALITY AND THE MODULAR HOME MANUFACTURING PROCESS

3.1 INTRODUCTION

The modular manufacturing process begins with the builder or consumer placing an order for a particular home and ends with final finish work in the field. This chapter divides this process into a series of distinct steps and describe how each step is, or is not, conducive to assuring the quality of the product. Since the principle component of quality is meeting and exceeding consumer expectations and needs, this analysis will be structured from a consumer's point of view. A model of the overall process is shown in Figure 3.1 [11].

3.2 SALES ORDER

The modular manufacturing process begins when a builder places a sales order on behalf of a consumer to have a particular

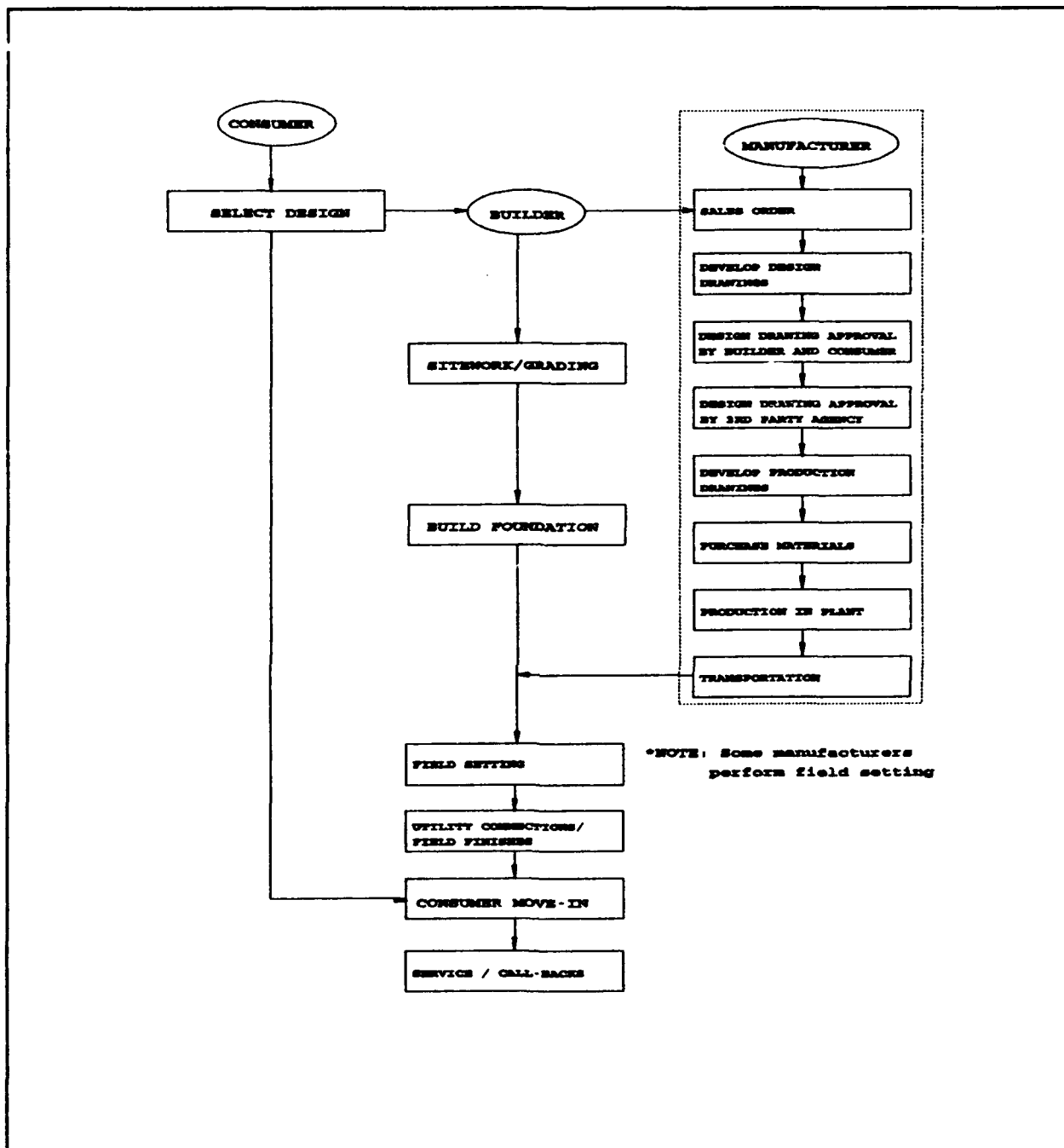


FIGURE 3.1 - MODULAR MANUFACTURING PROCESS (Source: [11])

home manufactured. Most manufacturers offer a portfolio of designs, which can be modified and customized to meet consumers'

specific needs. Prior to actual placement of an order, builders typically mediate between the manufacturer and the consumer to ensure that the manufacturer understands exactly what the consumer desires.

With the builder acting as a middleman in this process, consumers run the risk of having their needs and expectations misrepresented to, or misconstrued by the manufacturer. Consumers must be very careful to ensure that the manufacturer understands exactly what they are expecting. There are manufacturers who deal directly with consumers and others who spend time with both the builder and consumer in order to ensure that the needs and expectations of the consumer are clearly understood. It is the writer's opinion that consumers should seek manufacturers who routinely function in this latter manner in order to ensure that they get exactly what they need and expect.

3.3 DEVELOP DESIGN DRAWINGS

After the sales order has been placed, preliminary design drawings are developed by the manufacturer based on the sales order specifications. Designs are typically drawn using Computer Aided Drafting (CAD) Systems. These CAD systems increase the speed and efficiency with which designs can be produced. These systems also allow for faster design modifications, if requested

by the consumer or the builder.

Consumers must be careful to select a manufacturer whose Sales and Design Departments work very closely with each other. Again, as in the previous step, the potential exists for the needs and expectations of the consumer to be misconstrued between the two entities.

3.4 DESIGN DRAWING APPROVAL BY BUILDER AND CONSUMER

Manufacturers typically allow builders and consumers to review the completed design drawings. This gives consumers a chance to ensure that the design has incorporated all of their needs and expectations. Consumers with little exposure to design drawings should seek out a builder who is willing to take the time to help them understand the design and how it meets their needs and expectations or they will run the risk of not getting exactly what they are expecting.

3.5 DESIGN DRAWING APPROVAL BY THIRD PARTY AGENCY [11]

Modular home manufacturers are required by state laws to retain the services of state approved third party inspection agencies. These independent agencies inspect designs (and later the actual modules) to ensure conformance with state and national building codes. This gives consumers a built-in assurance that

their homes will meet applicable state and federal codes.

3.6 DEVELOP PRODUCTION DRAWINGS AND QUALITY CONTROL CHECKLIST

After the design has been approved by the builder, the consumer, and the cognizant third party inspection agency, manufacturers transform the designs into production drawings. These production drawings are used in the plant to build the modules that will create the home when bolted together in the field. These drawings will also be used by the manufacturer's Quality Control Department to generate in-plant inspection checklists. Reference [15] provides a detailed analysis of the development of an effective quality control plan.

If there weren't any problems with the initial design drawings, consumers can feel quite certain that the production drawings will accurately reflect their needs and expectations, since the production drawings are derived directly from the initial design drawings. Manufacturers who develop their quality control inspection checklists directly from the consumer-approved design drawings are assuring consumers that their home will be inspected for compliance with their needs and expectations during production.

3.7 PURCHASE MATERIALS

Finalized production drawings and the sales order are passed to the manufacturer's purchasing department where all of the materials for the home are ordered. Most of the materials to be used in the home have been specified by the consumer, either in the sales order or in the design drawings. The remainder of the materials are typically delineated in the manufacturer's standard specifications. Consumers must be sure that they clearly understand what these standard materials are and whether they meet their needs and expectations. Here again, it benefits the consumer to contract with a builder who is willing to take the time to help them clearly understand the advantages and disadvantages of these standard materials. Most manufacturers make it a paid option to upgrade their standard materials at the request of consumers.

Manufacturers typically inspect materials upon receipt, prior to introducing them into the production line. This step, which is usually performed by either the Purchasing Department or the Quality Control Department, is performed in order to ensure that materials comply with the manufacturer's quality standards and with the consumers needs and expectations. This minimizes the chance of poor quality or incorrect materials being used in the consumer's home.

3.8 PRODUCTION IN PLANT

Once materials have been properly screened and quality control inspection checklists have been finalized, production of the home begins inside the manufacturing plant. The layout of a typical modular housing plant is shown in Figure 3.2. As noted by Showan [11] for the plant he studied:

"Assembly begins at the floor, wall, and ceiling/roof framing stations concurrently. In addition to framing, interior gypsum board is attached to one side of the walls and the ceiling.

The main unit moves from the floor framing station to the floor sheathing station. Once the floor sheathing is attached the unit is moved to wall setting, Station 4, where the wall assemblies are placed on the finished floor system.

Preliminary finishing, Station 5, installs rough plumbing and applies the first coat of drywall joint compound. The unit continues to ceiling/roof setting, Station 7, where the ceiling/roof system is attached.

The unit then moves to intermediate finishing, Station 8, where plumbing and electrical systems are completed and tested, the second coat of joint compound is placed, and windows and doors are set. Insulation, exterior sheathing, roof sheathing, overhangs, tar paper, and roof shingles are attached at Station 9.

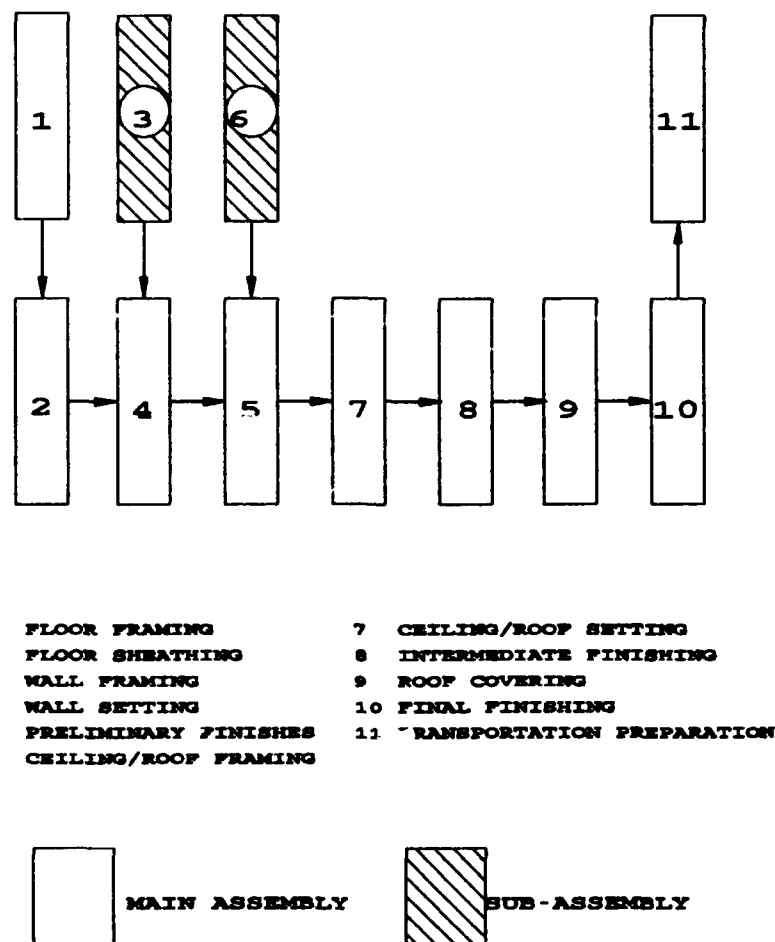


FIGURE 3.2 - TYPICAL MODULAR HOME PLANT LAYOUT (Source: [11])

The unit continues to final finishing, Station 10, where the third coat of drywall compound, soffits, siding, shutters, floor

coverings, molding, and trim are placed. Walls are painted, units are cleaned, ship-loose materials (materials to be installed in the field) are added, and exposed portions of the unit are covered at the transportation preparation station, Station 11. When the unit leaves this last station, it is a completed unit ready for transportation to a building site."

There are several advantages to producing homes in a factory environment such as this. The most obvious advantage is that the home is built indoors and thus remains protected from rain, wind, snow, and extreme swings in temperature and humidity. This minimizes the chance for warping, buckling, cupping, nail pops, and water damage occurring within the home.

Homes built in this manner are also intensely scrutinized by several parties, both internal and external to the manufacturer, in order to ensure compliance with plans, specifications, company standards, applicable state and federal building codes, and consumer needs and expectations. A detailed description of these multi-level inspections is contained in section 6.5 of Chapter 6.

This assembly-line environment also fosters a high degree of worker skill. Workers typically perform the same work task at the same station or stations for each home that is produced. The repetitive nature of this environment allows all workers along the line to develop a high degree of skill and proficiency in performing their work tasks. Workers are also provided with proper tools and equipment to ensure a high degree of proficiency

and consistency in their work, such as pneumatic nail guns, overhead cranes, airless paint spray applicators, and floor and wall framing jigs which ensure squareness of structural members.

One potential drawback to this assembly-line environment, if it is not properly managed, is that it could lead to an environment where workers are only concerned with performing their individual tasks at their individual stations. This situation could be very detrimental to the quality of the product. Manufacturers typically encourage consumers to tour their plants before placing a sales order and consumers should try to ascertain, if possible, the degree of teamwork among line workers and between stations before selecting a manufacturer. If management's understanding of quality concepts is shallow, this assembly-line setting may also lead to a company-wide focus on numerical goals , which is detrimental to assuring the quality of the product.

3.9 TRANSPORTATION [11]

Once the modules are completed and approved by all inspecting entities, they are loaded onto trailers and hauled to the home site. Each module must conform to various state highway transportation requirements concerning height, width, and weight. When planning a transportation route, special road limitations must be considered, and permits must be obtained. Transportation

costs vary with the length of haul.

Some manufacturers transport their own modules, while others subcontract this function. Consumers should inquire about this since a manufacturer who transports its own modules will probably take greater care to avoid module damage. During transport, modules typically experience some cracking in walls above doors and windows. These cracks are routinely repaired as part of the field finishing process, but consumers should look carefully for such cracks during final inspection of their home. Modules that aren't properly sealed and wrapped with plastic may also experience water damage during transportation.

3.10 FIELD SETTING

Once all modules are transported to the home site, they are lifted by crane, lowered and attached to the foundation, and bolted together. Some manufacturers perform this function themselves, while others leave this task to the builder. Manufacturers who perform this task with their own setting crews are usually very proficient and can set and bolt all units together and complete the roof (thereby making the house watertight) the same day. Consumers must be very careful if the setting function is left up to the builder. An inexperienced builder can have a great deal of trouble setting and connecting modules and could potentially cause visible or hidden damage to

the modules.

3.11 UTILITY CONNECTIONS/FIELD FINISHES

Major utility connections and field finishes are typically performed by the builder. Since most modules are 90 - 95% complete when they reach the home site, this step usually takes a minimal amount of time, typically ranging from two to three weeks. Since the final finish work is highly visible, consumers must be sure to select a builder who has a reputation for high quality workmanship.

3.12 SITE WORK/BUILD FOUNDATION

As depicted in Figure 3.1, site work and construction of the foundation are solely the responsibility of the builder. Proper construction of the foundation is extremely critical if the home modules are to seat properly and fit together properly. A poorly constructed foundation can lead to cracks in walls and ceilings, excessive air infiltration, water infiltration, and doors and windows that stick. Some manufacturers, but not all, inspect builders' foundations before delivering modules. Consumers can minimize the chance of experiencing the problems mentioned above by selecting such a manufacturer.

3.13 SERVICE/CALL-BACKS

It is in this step of the process that the consumer is exposed to the greatest risk of becoming dissatisfied. Depending on the particular builder and manufacturer, consumers may find themselves caught in the middle of a "responsibility contest" when defects arise after their home is completed. Consumers must be careful to select both a builder and a manufacturer who are known for the quality of their service, who have worked together for a period of time and who clearly understand each other's responsibilities.

3.14 SUMMARY

Due to the controlled environment of manufacturing plants, the repetitive nature of work performed on the production line, the intensity with which modular homes are scrutinized, and code compliance inspections performed by third party agencies, the modular home manufacturing process is highly conducive to producing high quality homes. All modular manufacturers have a Quality Control Department that is dedicated to ensuring that all homes produced are in accordance with applicable codes, company standards, and design drawings and specifications which ideally reflect the needs and expectations of consumers. There are also certain aspects of the manufacturing plant process that, if not

properly managed, could lead to a poor quality product.

It cannot be concluded that all modular home manufacturers produce high quality homes. Those manufacturers who place the highest amount of importance on meeting and exceeding consumer expectations and needs will best be able to utilize the advantages offered by a manufacturing plant environment to consistently and economically produce homes that are recognized as high quality homes. The writer feels that consumers who carefully select both a reputable manufacturer and builder can feel quite comfortable that they will be purchasing a home of exceptional quality.

CHAPTER 4

ASSESSMENT OF MODERN QUALITY MANAGEMENT PRACTICES IN THE MODULAR HOME INDUSTRY

4.1 INTRODUCTION

This chapter assesses the degree to which the three participating manufacturers are employing modern quality management techniques. The assessments are based on an outline of an ideal modern quality management plan for a typical modular manufacturer which was developed from the basic elements of modern quality management described in Chapter 2. The outline is listed in Appendix B. Since the outline has been developed for a "typical" modular manufacturer, the elements of the plan are listed in a generic fashion. This outline can be modified to fit individual manufacturers by adding more detailed information that is pertinent to the operations of the individual manufacturer.

4.2 METHODOLOGY

Each line item of the ideal quality management plan outline was assigned a value of one point. Based on interviews with company employees and direct observations, a determination was made about whether or not each line item was being practiced by the manufacturer being interviewed. One point was given for each line item that was in effect at the time of the interviews. A score of zero was given for line items not in effect. An appropriate fraction of one point was given for each line item that was partially in effect. The scores for each of the line items were then added together for a total score. The highest possible score was 128 points.

As will be noted in Appendix B, the outline is divided into 15 sections, each of which addresses one of the basic elements of modern quality management presented in Chapter 2. Since opinions may differ as to the weight that each of these elements carries, no weightings were assigned to individual categories. Each line item was given the same value of one point. This approach allowed for a determination of which elements were being employed and which elements were not, thereby highlighting areas of possible improvement. Scoring breakdowns for each manufacturer are listed in Table 4.1.

4.3 ASSESSMENT OF MANUFACTURER A: TOTAL SCORE = 89.05/128

Manufacturer A has produced an average of 700 single family homes annually over the past 5 years with an average annual single family sales volume of 21 million dollars. Manufacturer A recently instituted a new quality management program which was not yet fully operational at the time of the plant visit. Accordingly, manufacturer A received partial scores of less than one point for several of the line items which were not yet fully in effect. The writer feels, however, that manufacturer A's total score will increase considerably after the new program is fully implemented.

TABLE 4.1 SUMMARY OF QUALITY MANAGEMENT RATINGS

QUALITY MANAGEMENT CATEGORY	POSSIBLE SCORE	MFCTR A SCORE	MFCTR B SCORE	MFCTR C SCORE
1.) Role of Management	23	18	22	22
2.) Quality Policy	6	0	5.5	4
3.) Role of Lineworker	18	10	10.75	17.5
4.) Designing for Quality	14	14	12.25	14
5.) Role of Sales & Mktg.	6	4.5	6	5
6.) Quality of Materials	8	5	7.5	8
7.) Quality of Mfctg. Process	8	6.5	6	8
8.) Quality Improvement	2	2	2	2
9.) Feedback Loops	4	3.3	3.5	4
10.) Training	6	2	4.25	4
11.) Quality Audits	4	3.3	3.5	3.5
12.) Quality Control	11	9	11	10
13.) Role of Quality Dept.	10	7.25	7.5	5.75
14.) Costs of Poor Quality	3	2	1.5	1.5
15.) Role of Builder	5	2	4.5	5
TOTAL SCORE:	128	89.05	107.75	114.25
PERCENTAGE:		70%	84%	89%

4.3.1 Manufacturer A - Strongpoints

Manufacturer A's strongest area is in the Engineering and Design Department. This area (Designing for Quality) received a score of 14 out of a possible 14 points. This department is thoroughly familiar with the needs and expectations of consumers and continually strives to give customers what they want with no detail being too small to overlook.

Top management is sincerely committed to producing homes of the highest possible quality, and is actively leading the new quality management effort. Management also understands the importance of developing a reputation for quality and focusing on the long-term profits which result from a concentrated effort on quality rather than focusing on short-term profits. The company also holds regular meetings to discuss the progress of quality improvement efforts and the new quality management program.

The new quality management program focuses on doing the job right the first time. The plant has been divided into zones, with a designated leader in charge of each zone. All zone leaders jointly inspect each module and agree on conformance to requirements before it moves into the next zone. This approach appears to be resulting in each of the following improvements in the company's approach to quality:

1. Teamwork approach to ensuring quality.
2. Conformance decision is the responsibility of the line

foremen, not the Quality Control Department.

3. Fostering employee suggestions for process and product improvement.
4. Developing a sense of ownership of product among employees.
5. Minimizing costs of poor quality (re-work, waste, call-backs, inspection costs, etc.).
6. Allowing the Quality Department to concentrate on the overall quality management effort rather than quality control/conformance inspections.
7. Emphasizes the TRIPROL [7] function of each station on the line (i.e. viewing the next station down line as the customer).

Feedback loops are well established within the company and problems and defects are traced to their root sources and eliminated at their source. Inspection results are maintained in a computerized database for easy recognition of reoccurring problems and defects. The company has a good working relationship with third party inspectors. Costs of poor quality have been clearly identified by the Quality Department and are recognized and understood by management.

4.3.2 Manufacturer A - Areas of Possible Improvement

The company does not have a formal Quality Policy Statement,

nor does it have a standard definition of quality. The following list of definitions of quality were provided by various employees of the company during the site visit:

1. Meeting customer requirements (most common definition).
2. Doing the job right the first time.
3. Structural integrity.
4. Aesthetic appeal/cosmetic perfection.
5. Durability.

It would benefit the company to establish a standard definition of quality and incorporate this definition into a Quality Policy Statement that is understood and practiced by all employees in all aspects of their work. This would unify the company's approach to producing high quality homes and further the team approach to quality management. Based on interviews with various employees, an appropriate Quality Policy Statement for manufacturer A would be:

"It is the goal of each employee of our firm to consistently meet and exceed the requirements of our customers the first time down the line."

Quality Control and Engineering personnel receive building code training. Bill of Materials personnel receive cost training. Line workers receive basic tool skills training and on-the-job skills training. All new employees receive safety

training, hazard communications training and company policy training. Manufacturer A does not, however, have an established formal quality training program. The writer feels that a perpetual quality training curriculum which educates all employees about quality concepts, the company's quality policy and quality goals, the importance of the customer, quality improvement techniques, and the overall manufacturing process would further enhance the company's ability to consistently produce homes of the highest possible quality.

Although management has a thorough understanding of quality concepts and commitment to quality, this understanding and commitment has not, as yet, reached the level of the line worker. It would appear to be worthwhile to spend the time and effort to familiarize line workers with the company's quality goals and policies and to make them more aware of the importance of quality improvement techniques and "doing the job right the first time."

4.4 ASSESSMENT OF MANUFACTURER B: TOTAL SCORE = 107.75/128

Manufacturer B has produced an average of 400 single family homes annually over the past five years with an average annual single family sales volume of \$24 million. Manufacturer B has been developing and instituting a company-wide comprehensive quality management system for the past one and one half years.

4.4.1 Manufacturer B - Strongpoints

Manufacturer B's strongest area was in the role management is playing in leading and supporting the company's quality effort. This area (the role of management) received a score of 22 out of a possible 23 points. The effectiveness of the company's efforts toward instituting a sound quality management program over the past one and one half years is very apparent at the management level. All management personnel have a thorough understanding of what constitutes quality, and quality management concepts and techniques. Management realizes that quality improvement is a long-term process and has turned its focus toward long-term profits and reputation for quality, rather than focusing on short-term profits. Quality audits are performed on a monthly basis. Meetings are regularly scheduled to discuss the quality of materials, processes, product, and quality improvement. The company also regularly schedules Builder Action Council meetings to receive feedback and suggestion from builders, and to identify builder/consumer needs and expectations. Management also stresses the importance of doing the job right the first time and the importance of the team approach to quality.

Another strong point of Manufacturer B's quality effort is in the role of the sales and marketing department. This area received a score of 6 out of a possible 6 points. This division

of the company continually strives to keep abreast of builder and consumer needs and expectations and realizes the importance of meeting and exceeding those needs and expectations. This division also ensures that this information is passed to all other divisions of the company.

The company is also very focused on quality improvement. Every employee interviewed realized the importance of quality improvement and felt that there was still a great deal of room for further improvement.

The company's quality control effort is also very effective. This area received a score of 11 out of a possible 11 points. The system is very effective in detecting discrepancies and allows workers to make conformance decisions. All inspection findings are fed into a database for analysis and easy recognition of reoccurring problems. Discrepancies are traced to their root source and eliminated at the source. A very minimal number of discrepancies are found by Third Party Inspectors. The company also allows foremen from the production line to work in the Quality Department for thirty day periods, thereby developing an understanding of quality requirements on the production line.

4.4.2 Manufacturer B - Areas of Possible Improvement

The area with the greatest room for improvement is in the role of the worker. Although management understands that workers

are an extremely important source of suggestions, there is no focused effort toward soliciting and encouraging such suggestions. The workers are still at a stage where they are somewhat intimidated by management and they do not fully believe that management will take their suggestions seriously enough to follow up on them and implement them.

In addition to feedback loops from the production line not being firmly established, line workers are not familiar with the quality goals and policies of the company. All workers are introduced to the company's quality process and policy when they are first hired, but receive no subsequent training or exposure to the company's quality goals and policies. Regularly scheduled quality training sessions or quality discussions among line workers should serve to increase their awareness of the quality process, and make quality and doing the job right the first time a part of their mindset.

A final area in which Manufacturer B could improve is in identifying the costs of poor quality. All personnel interviewed realized that quality improvement efforts were resulting in cost savings, but the actual dollar figures have never been identified. It should benefit the company's quality management effort to identify the specific costs of poor quality and to use these costs as a gauge of the effectiveness of the quality improvement effort.

4.5 ASSESSMENT OF MANUFACTURER C: TOTAL SCORE = 114.25/128

Manufacturer C has produced an average of 120 single family homes over the past five years, with an average annual single family sales volume of \$4.5 million. Historically, the company has held a reputation as a producer of high quality homes [12,13]. Manufacturer C's home prices are typically higher than other competitors, but consumers are still willing to pay extra for the extra quality they believe that they will receive in a home produced by Manufacturer C [14]. Accordingly, the company has been concentrating on quality and quality management for many years in order to live up to its well established reputation.

4.5.1 Manufacturer C: Strongpoints

Manufacturer C is a relatively small company with a relatively small number of employees (approximately 30 production and 20 administrative/management personnel). This unique setting has resulted in a very strong sense of teamwork and very well established lines of communication within the company. These factors, coupled with the company's long-standing focus on quality and quality management, contributed to perfect scores in each of the following categories:

1. Designing for Quality
2. Quality of Materials

3. Quality of Manufacturing Process
4. Quality Improvement
5. Feedback Loops
6. Role of Builders

The company also received a score of 22 out of a possible 23 points for the role management is playing in leading and supporting the company's quality effort, and a score of 17.5 out of a possible 18 points for the role of the workers.

The company's design department is very sensitive to the needs and expectations of builders and consumers. The department typically designs custom homes and regularly makes design modifications to standard floor plans and designs. The department constantly strives to meet the needs and expectations of builders and consumers and looks for ways to exceed these needs and expectations. The design department works very closely with the production line in searching for ways to improve all designs.

The company uses high quality name-brand materials and components and realizes the importance of using such materials to consistently meet and exceed consumer needs and expectations. Choice of suppliers is limited to one or two for each type of material or component and is not based on price alone.

Due to the small size of the manufacturing plant and the small size of the production crew, a very strong emphasis is placed on quality at all points along the production line.

Workers are very much aware of the reputation of the product they build and are therefore very sensitive to performing their tasks correctly. Workers feel free to make suggestions for improving the process and the product and work very well together as a team. Workers generally have a very good understanding of the overall production process. Management within the production division ensures that quality is the number one focus of everyone's task and actively ensures that numerical goals are secondary to quality goals.

Feedback loops are well established at all levels within the company. All problems are traced to their root sources and eliminated with a teamwork approach. External feedback loops are also well utilized to ensure builder and consumer satisfaction and to keep in touch with their needs and expectations.

Builders of Manufacturer C's homes understand the importance of meeting consumer needs and expectations and living up to Company C's reputation for quality. Builders participate in quarterly Builder Advisory Council meetings with Manufacturer C at which time common problems are identified and resolved.

Management has a very good understanding of quality management concepts and techniques and is sincerely committed to maintaining the company's reputation as a producer of high quality homes. Accordingly, management's focus is on long-term profits. Management also realizes that quality is a part of the culture of the company and strives to strengthen and nurture the

quality "mindset" that exists throughout the company since quality homes are nearly an automatic end product of this mindset.

4.5.2 Manufacturer C - Areas of Possible Improvement

Because the quality mindset is so well ingrained in the company, and because of the fact that the company has focused on managing the quality of its product for such a long time, there are no areas with a great deal of room for improvement. There are, however, some minor areas in which the company can make beneficial improvements.

The company has no formal quality policy statement or quality training program. Currently, there is not a strong need for either since the small number of personnel currently employed have a thorough understanding of the company's quality goals, and what it takes to produce a high quality home. However, should the company experience a sudden increase in personnel, it would run the risk of introducing non-quality-oriented personnel into its well groomed organization. The writer feels, therefore, that it would benefit the company to formalize such a quality policy statement and quality training program so that it would be prepared to properly instill the quality mindset of the company in the minds of new employees before introducing them into the organization.

The company has also not identified the costs it incurs as a result of poor quality. Although these costs may be limited at this point in time, it would benefit the company to identify these costs. Specifically identifying and quantifying these costs will provide the company with an excellent tool for financially managing its quality efforts. Including these costs in the company's regular cost reporting system will allow management to monitor and control these costs and the overall quality effort. This should prove to be very valuable when the production volume increases since increases in volume can lead to decreased product quality if no such means of monitoring and controlling the costs of poor quality are in place.

4.6 SUMMARY

This chapter has attempted to measure the degree to which the three participating manufacturers are employing modern quality management techniques. Although none of the manufacturers are completely satisfying every line item of the ideal quality management plan outline listed in Appendix B, all three are practicing a majority of these items in their day to day operations (see table 4.1).

Management is playing a strong role in leading the quality management/quality improvement efforts of all three companies. All three companies have very effective quality control plans and

are very intent on constantly improving the quality of their homes. All three companies place strong emphasis on the quality of their designs and the majority of personnel within each company understand the importance of meeting and exceeding builder and homebuyer needs and expectations.

All three manufacturers could improve their quality training programs and two out of three need to develop their line workers' understanding of quality concepts and quality improvement (this is a management deficiency, not a worker deficiency). All three manufacturers should also find it beneficial to more accurately quantify the costs of poor quality.

Although all three manufacturers are employing a majority of the line items of the ideal quality management plan outline (70% to 89%) one cannot necessarily conclude from this small sample that this represents the quality management efforts of the modular home industry as a whole. This may, however, be an indication that the modular home manufacturing process fosters a strong focus on managing the quality of the product. The methodology used within this chapter may prove useful to builders and homebuyers who are seriously concerned about the quality management efforts of various modular home manufacturers. A rating scale which is based upon the ideal quality management plan may be an excellent comparison tool that a consumer could use when selecting the manufacturer of his/her home. Modular home manufacturers can also use this rating system to analyze and

monitor their own quality management efforts. With minor modifications, all Systems Built Housing Manufacturers can also use this rating system.

CHAPTER 5

BUILDER AND CONSUMER PERCEPTIONS OF MODULAR HOME QUALITY

5.1 INTRODUCTION

The most effective means of measuring the quality of a product is by determining whether it meets and exceeds consumer needs and expectations. In this regard, the typical modular home manufacturer should be concerned with meeting and exceeding the needs and expectations of two customers. The first is the immediate customer - the builder who erects the homes. The second is the consumer - the homebuyer. This chapter analyzes the degree to which the three participating manufacturers are meeting and exceeding builder and consumer expectations and also presents builder and consumer definitions of a quality home.

5.2 METHODOLOGY

Builder and consumer questionnaires, listed in Appendices C

and D respectively, were developed and distributed. The questions were divided into the following categories:

<u>Builder</u>	<u>Consumer</u>
Quality of Manufacturer's Service	-
General Quality of Modules	-
Quality of Floors	Quality of Floors
Quality of Interior Walls	Quality of Interior Walls
Quality of Ceilings	Quality of Ceilings
Quality of Exterior Walls	Quality of Exterior Walls
Roof Quality	Quality of Roofs
Quality of Windows	Quality of Windows
Quality of Doors	Quality of Doors
Quality of Plumbing Systems	Quality of Plumbing Systems
Quality of Electrical Systems	Quality of Electrical Systems

Each category contained a series of questions which prompted builders and consumers to identify both what they expected to receive and what they actually received in their homes. This resulted in an easy interpretation of whether builder and consumer expectations were not met, met, or exceeded. If a builder or consumer received exactly what they expected, their needs and expectations were considered "met." If they received less than what they expected, their needs and expectations were considered "not met." If they received a better product than

TABLE 5.1 - PROFILE OF BUILDER AND CONSUMER RESPONSES

BUILDER SURVEY:

	<u># Polled</u>	<u># Responses</u>	<u>% Response</u>
Manufacturer A	12	3	25
Manufacturer B	50	5	10
Manufacturer C	<u>50</u>	<u>12</u>	<u>24</u>
Total	112	20	18

CONSUMER SURVEY:

	<u># Polled</u>	<u># Responses</u>	<u>% Response</u>
Manufacturer A	38	8	21
Manufacturer C	<u>50</u>	<u>18</u>	<u>36</u>
Total	88	26	30

they expected, their needs and expectations were considered "exceeded." Each category was then analyzed by tallying the number of "not met," "met," and "exceeded" responses, and expressing each as a percentage of the total number of responses. Builders and consumers were also asked to designate an overall quality rating of excellent, good, fair, or poor for each category.

A profile of the number of surveys distributed and the number of responses received is contained in Table 5.1. Builders and consumers were randomly selected from the manufacturers' mailing lists. Since this report is analyzing quality in the modular housing industry, builder and consumer responses from all

three manufacturers were consolidated and analyzed as a whole (the overall survey ratings for each manufacturer are provided in Tables 5.3 and 5.6, but detailed individual analyses of each manufacturer have not been included in this report for reasons of confidentiality). It should be noted that a list of consumers was not available for manufacturer B.

5.3 BUILDER SURVEY

TABLE 5.2 - MODULAR HOME PRICE RANGES (Builder Survey)

<u>PRICE RANGE</u>	<u># OF HOMES</u>	<u>% OF TOTAL</u>
\$30,000 - \$50,000	22	13%
\$50,001 - \$70,000	24	14%
\$70,001 - \$90,000	66	38%
\$90,001 - \$110,000	3	2%
\$110,001 - \$150,000	10	6%
over \$150,000	47	27%
Total	172	100%

(*Note: PRICE = Price to consumer)

Of the twenty builder responses received, 15% were from manufacturer A builders, 25% were from manufacturer B builders, and 60% were from manufacturer C builders. These twenty builders erected an average of 8.6 modular homes each within the past year. Table 5.2 indicates the price ranges of the homes that

these builders erected. The average home size was 1292 square feet.

Table 5.3 contains a summary of the builders' responses. A more detailed breakdown is provided in Appendix E. The remainder of this section analyzes builder responses within each category.

5.3.1 Quality of Manufacturer's Service

This category received the highest rating with 91% of builders' expectations being met or exceeded. Builders' expectations were exceeded more in this category than in any other. Builders expectations were primarily exceeded in the area of special design requests. Builders' expectations were not met 9% of the time, primarily in the area of design errors. Builders overall quality ratings for this category were:

Excellent:	42%
Good	: 53%
Fair	: 5%
Poor	: 0%

5.3.2 General Quality of Modules

In this category 69% of builders' expectations were met or exceeded, with no area being highlighted as exceeding builders'

TABLE 5.3 - SUMMARY OF BUILDER RESPONSES

Combined Responses (Mfctr A + Mfctr B + Mfctr C):

<u>CATEGORY</u>	BUILDER EXPECTATIONS:		
	<u>Not Met</u>	<u>Met</u>	<u>Exceeded</u>
1.) Quality of mfctr's. service	9%	61%	30%
2.) General quality of modules	31%	66%	3%
3.) Quality of floors	18%	75%	7%
4.) Quality of interior walls	30%	64%	6%
5.) Quality of ceilings	25%	70%	5%
6.) Quality of exterior walls	22%	72%	6%
7.) Roof quality	23%	72%	5%
8.) Quality of windows	13%	76%	11%
9.) Quality of doors	34%	56%	10%
10.) Quality of plumbing systems	30%	66%	4%
11.) Quality of electrical systems	<u>30%</u>	<u>69%</u>	<u>1%</u>
TOTAL (all categories combined)	25%	68%	7%

Individual Manufacturer Responses:

	<u>Not Met</u>	<u>Met</u>	<u>Exceeded</u>
TOTAL - Manufacturer A	48%	49%	3%
TOTAL - Manufacturer B	29%	55%	16%
TOTAL - Manufacturer C	17%	78%	5%

expectations. The primary areas where builder expectations were not met related to "squareness of walls" and "ship loose materials." Incorrect or insufficient ship loose materials is a fairly common problem within the industry and all 3 manufacturers

in this study have been concentrating on improving in this area. Guaranteed "squareness of walls" is one of the major claims of the industry and it is therefore surprising to note that the expectations of all builders were not met or exceeded in this area. Builders' overall quality rating for this category were:

Excellent:	37%
Good	: 42%
Fair	: 21%
Poor	: 0%

5.3.3 Quality of Floors

This category scored well, with builders' expectations being met or exceeded 82% of the time. Builder's expectations were primarily exceeded in the "rigidity of floors" area. The primary areas where builder expectations were not met related to visible carpet seams and cuts or tears in sheet vinyl floors. Builders' overall quality ratings for this category were:

Excellent:	42%
Good	: 47%
Fair	: 11%
Poor	: 0%

5.3.4 Quality of Interior Walls

In this category, 70% of the builders' expectations were met or exceeded, with no area being highlighted as greatly exceeding builders' expectations. The primary areas where builder expectations were not met related to nail pops and crooked and uneven corners. Again, guaranteed squareness of walls is a major claim of the industry and it is therefore surprising that all builders' expectations were not met or exceeded in this area. Builder's overall quality ratings for this category were:

Excellent:	53%
Good	: 16%
Fair	: 21%
Poor	: 10%

5.3.5 Quality of Ceilings

This category scored fairly well, with 75% of builders' expectations being met or exceeded, and with no area greatly exceeding builders' expectations. The primary areas where builder expectations were not met related to "noticeable ceiling joints" and "evenness of paint." Builders' overall quality ratings for this category were:

Excellent:	47%
Good	: 37%

Fair : 16%
Poor : 0%

5.3.6 Quality of Exterior Walls

This category also scored fairly well, with 78% of builders' expectations being met or exceeded. Builders' expectations were not greatly exceeded in any particular area. The primary areas where builder expectations were not met were related to buckles and gaps in siding. Builders' overall quality rating for this category were:

Excellent: 42%
Good : 42%
Fair : 16%
Poor : 0%

5.3.7 Roof Quality

This category scored fairly well, with 77% of builders' expectations met or exceeded. Builders' expectations were not greatly exceeded in any particular area. Roof bulges and sags, and tilt-up roofs not matching properly at the ridgeline were listed as the primary problem areas. Builders' overall quality ratings for this category were:

Excellent: 37%

Good	:	59%
Fair	:	4%
Poor	:	0%

5.3.8 Quality of Windows

This category scored well, with 87% of builders' expectations being met or exceeded. Builders' expectations were not greatly exceeded in any particular area. The improper use of flashing appeared to be the primary problem area. Builders' overall quality ratings for this category were:

Excellent:	63%	
Good	:	32%
Fair	:	5%
Poor	:	0%

5.3.9 Quality of Doors

This category received the poorest rating, with 66% of builders' expectations being met or exceeded. Builders' expectations were not greatly exceeded in any particular area. Drafts and leaks around exterior doors appeared to be the primary problem areas. Builders' overall quality ratings for this category were:

Excellent:	47%
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Good : 24%
Fair : 24%
Poor : 5%

5.3.10 Quality of Plumbing Systems

In this category, 70% of builders' expectations were met or exceeded. Builders' expectations were not greatly exceeded in any particular area. Leaks within the system, and broken pipes and fittings were identified as the primary areas where builder expectations were not met. It is interesting to note that 4% of builders' expectations were not met in the area of code compliance. Builders' overall quality ratings for this category were:

Excellent: 32%
Good : 47%
Fair : 10.5%
Poor : 10.5%

5.3.11 Quality of Electrical Systems

In this category 70% of builders' expectations were met or exceeded. Builders' expectations were not greatly exceeded in any particular area. Primary areas of concern included "discrepancies from plans" and "faulty receptacles." It is

interesting to note that 4% of builders' expectations were not met in the area of code compliance. Builders' overall quality ratings for this category were:

Excellent:	44%
Good	: 50%
Fair	: 6%
Poor	: 0%

5.3.12 Builder Perceptions of General Quality

Builder responses to several of the general questions that were asked in the builder surveys are analyzed in this section.

A. Builders were asked if there were any aspects of modular homes that greatly exceeded their expectations. The responses to this question were:

1. General quality of homes and materials used.
2. Speed of delivery and erection.
3. Meeting delivery dates.
4. Manufacturer's service and help in resolving problems.
5. Design diversity.
6. Superior structural quality.
7. Superior energy efficiency.
8. So few problems.
9. Little or no problems with building inspectors.

B. Builders were also asked if there were any aspects of modular homes that fell far short of their expectations. The responses to this question were:

1. Exterior doors.
2. Drywall/finish workmanship.
3. Difficulty of matching paint.
4. Plumbing mistakes.
5. Tightness.
6. Matching of some marriage walls.

C. Builders were asked to indicate the type of responses they would give to other builders interested in building modular homes. Their responses to this question were:

	<u>% of Builders Surveyed</u>
Strongly recommend to build	60%
Recommend to build	35%
Indifferent	5%
Recommend not to build	0%
Strongly recommend not to build	0%

D. Builders were also asked if they prefer to build modular or stick-built homes. One hundred percent preferred building modular over stick-built. Builders' reasons for preferring modular, over stick-built, were:

1. Homes are built in a protected, controlled environment,

with no exposure to rain, snow, cold, wind, etc.

2. Quick turnaround time (* most common response).
3. Guaranteed delivery time.
4. Better quality.
5. Cost control - no financial surprises or cost overruns;
save on construction loans.
6. Requires less management and smaller organization.
7. Reduces problems with subcontractors.
8. Superior structural quality.
9. Ability to build during winter months.
10. Less waste, clean operation, more efficient home.
11. Tighter house, better energy efficiency.
12. Ability to customize.
13. Manufacturer's service.

E. Builders were also asked to give their own definitions of a high quality home. They gave a wide variety of definitions which have been consolidated, and summarized, in Table 5.4. As noted, the survey did not derive a common builder definition of a high quality home. However, the definitions provided could be viewed as the common, general expectations of builders, which modular home manufacturers should strive to consistently meet and exceed.

TABLE 5.4 - BUILDER DEFINITIONS OF A HIGH QUALITY HOME

- 1.) A house built with very good construction practices and workmanship, with good attention to details and finish work.
 - 2.) A house with no defects and no service calls after completion of punch list.
 - 3.) A house in which high quality materials are used.
 - 4.) A rigid, durable structure with walls straight and square.
 - 5.) A house that is custom designed.
 - 6.) A house that is energy efficient.
 - 7.) A house with a practical floor plan.
-

5.4 SUMMARY OF BUILDER SURVEY

As shown in Table 5.3, the manufacturers of this study met or exceeded builder expectations 75% of the time. This seems to be a respectable value, although it cannot be compared with other published information since it appears that a similar survey has not been previously conducted. The remaining 25% of builders' expectations that were not met, indicate that there is room for improvement in meeting or exceeding builders' expectations. It is interesting to note that although builders' expectations were met or exceeded 75% of the time, their expectations were exceeded only 7% of the time. This figure indicates that there is much room for improvement in exceeding builders' expectations.

The categories in which builders' expectations were best met were: 1. Quality of Manufacturer's Service, 2. Quality of Windows, and 3. Quality of Floors. In these three categories, builders' expectations were met or exceeded 91%, 87%, and 82% of the time, respectively.

The categories in which builders' expectations were most poorly met were: 1. Quality of Doors, 2. General Quality of modules (i.e. fit and compatibility), and 3. Quality of Plumbing and Electrical Systems. Although these three categories received the poorest ratings, builders' expectations were still met or exceeded in each 66%, 69%, and 70% of the time, respectively.

5.5 CONSUMER SURVEY

The format of the consumer survey is almost identical to the format of the builder survey. As mentioned previously, however, a list of consumers was not available for manufacturer B. This resulted in a consumer data set that is slightly different from the builder data set since it only surveyed consumers of manufacturers A and C.

Of the 26 consumer responses received, 31% were from manufacturer A consumers, and 69% were from manufacturer C consumers. Table 5.5 indicates the price ranges of the homes included in the survey.

Table 5.6 contains a summary of the consumers' responses. A

TABLE 5.5 - MODULAR HOME PRICE RANGES (Consumer Survey)

<u>PRICE RANGE</u>	<u># OF HOMES</u>	<u>% OF TOTAL</u>
\$30,000 - \$50,000	2	8%
\$50,001 - \$70,000	10	38%
\$70,001 - \$90,000	6	23%
\$90,001 - \$110,000	3	12%
\$110,001 - \$150,000	3	12%
over \$150,000	<u>2</u>	<u>7%</u>
Total	26	100%

(*Note: PRICE = lot + foundation + finished home)

more detailed breakdown is contained in Appendix F. The remainder of this section analyzes consumer responses within each category.

5.5.1 Quality of Floors

This category scored fairly well, with 75% of consumers' expectations being met or exceeded. Consumers' expectations were not greatly exceeded in any particular area of this category. Consumers' expectations were not met 25% of the time, primarily in the areas of visible carpet seams and bumps/bulges in floor finishes. Consumers' overall quality ratings for this category were:

Excellent: 35%

Good : 46%

TABLE 5.6 - SUMMARY OF CONSUMER RESPONSES

Combined Responses (Mfctr A + Mfctr C):

<u>CATEGORY</u>	<u>CONSUMER EXPECTATIONS:</u>		
	<u>Not Met</u>	<u>Met</u>	<u>Exceeded</u>
1.) Quality of floors	25%	69%	6%
2.) Quality of interior walls	22%	70%	8%
3.) Quality of ceilings	16%	77%	7%
4.) Quality of exterior walls	13%	81%	6%
5.) Roof quality	11%	87%	2%
6.) Quality of windows	8%	90%	2%
7.) Quality of doors	25%	73%	2%
8.) Quality of plumbing systems	19%	80%	1%
9.) Quality of electrical systems	7%	87%	6%
TOTAL (all categories combined)	17%	78%	5%

Individual Manufacturer Responses:

	<u>Not Met</u>	<u>Met</u>	<u>Exceeded</u>
TOTAL - Manufacturer A	25%	74%	1%
TOTAL - Manufacturer C	10%	84%	6%

Fair : 15%

Poor : 4%

5.5.2 Quality of Interior Walls

This category also scored fairly well, with 78% of consumers' expectations being met or exceeded. Consumers'

expectations were not greatly exceeded in any particular area. Nail pops and cracks in wallboard were the primary areas where consumer expectations were not met. This may be an indication that all cracks and surface defects are not repaired by builders prior to consumer move-in. Consumers' overall quality ratings for this category were:

Excellent:	31%
Good	: 58%
Fair	: 11%
Poor	: 0%

5.5.3 Quality of Ceilings

This category scored well, with 84% of consumers' expectations being met or exceeded. Consumers' expectations were not greatly exceeded in any one area. The primary area where builder expectations were not met related to cracks in ceiling board. Consumers' overall quality ratings for this category were:

Excellent:	46%
Good	: 38%
Fair	: 15%
Poor	: 0%

5.5.4 Quality of Exterior Walls

This category also scored well, with 87% of consumers' expectations being met or exceeded. Consumers' expectations were not greatly exceeded in any particular area. Buckles and gaps in siding were listed as the primary problem areas. Consumers' overall quality rating for this category were:

Excellent:	62%
Good	: 19%
Fair	: 15%
Poor	: 4%

5.5.5 Roof Quality

This category also scored well, with 89% of consumers' expectations being met or exceeded. Consumers' expectations were not greatly exceeded in any particular area. Shingles not laying down properly appeared to be the primary problem area.

Consumers' overall quality rating for this category were:

Excellent:	60%
Good	: 32%
Fair	: 8%
Poor	: 0%

5.5.6 Quality of Windows

This category scored very well, with 92% of consumers' expectations being met or exceeded. Consumers' expectations were not greatly exceeded in any particular area. Drafts and thermal effectiveness appeared to be the primary areas where consumer expectations were not met. Consumers' overall quality ratings for this category were:

Excellent:	78%
Good	: 11%
Fair	: 11%
Poor	: 0%

5.5.7 Quality of Doors

This category scored fairly well, with 75% of consumers' expectations being met or exceeded. Consumers' expectations were not greatly exceeded in any particular area. The primary areas where consumer expectations were not met related to doors swinging far enough to damage walls, and doors that stick. Consumers' overall quality ratings for this category were:

Excellent:	31%
Good	: 58%
Fair	: 11%
Poor	: 0%

5.5.8 Quality of Plumbing Systems

This category scored well, with 81% of consumers' expectations being met or exceeded. Consumers' expectations were not greatly exceeded in any particular area. Low system pressure and leaks within the system were identified as the primary areas where builder expectations were not met. Low system pressure is probably not the modular manufacturers' problem, but they should be aware of the fact that consumers are somewhat concerned with this problem. Consumers' overall quality ratings for this category were:

Excellent: 42%

Good : 38%

Fair : 15%

Poor : 5%

5.5.9 Quality of Electrical Systems

This category received the highest rating, with 93% of consumers' expectations being met or exceeded. Consumers' expectations were primarily exceeded in the areas of numbers and locations of wall receptacles. There were no pronounced problem areas within this category. Consumers' overall quality ratings for this category were:

Excellent: 68%

Good : 24%
Fair : 18%
Poor : 0%

5.5.10 Consumer Perceptions of General Quality

Several general questions were asked in the consumer surveys. This section analyzes consumers' responses to these questions.

A. Consumers were asked if there were any aspects of their modular homes that greatly exceeded their expectations. The responses to this question were:

1. Layout; floor plan (*most common response).
2. Design, ease of design changes, and ability to customize design.
3. Tightness; energy efficiency.
4. Quality of materials.
5. Solid structure.
6. Extras added at no expense.
7. Overall appearance.
8. Overall quality.

These responses are considered random and isolated and are not considered representative of the entire sample population. They do, however, indicate the areas in which manufacturers A and B successfully exceeded one or more consumers' expectations.

B. Consumers were also asked if there were any aspects of their homes that fell far short of their expectations. The responses to this question were:

1. Quality of finish workmanship.
2. Door, window, and roof problems.
3. Builder related problems including: a. unfinished punch list items, b. foundation problems, and c. promised work not performed.
4. Plumbing system.
5. Electric heat extremely costly.

Again, these responses are random and isolated and are not considered representative of the entire sample population. They do, however, indicate areas in which modular manufacturers A and C were not successful in meeting or exceeding the expectations of one or more consumers. The writer feels that manufacturers A and C should not consider item 3. above as strictly a "builder problem." Unsatisfied consumers should be taken seriously no matter what the cause of their dissatisfaction may be.

C. Consumers were also asked to provide their own definitions of a high quality home. They gave a wide variety of definitions which have been consolidated, and summarized, in Table 5.7.

As can be seen in Table 5.7, the survey did not derive a common consumer definition of a high quality home. However, the definitions provided should be viewed as common, general

TABLE 5.7 - CONSUMER DEFINITIONS OF A HIGH QUALITY HOME

- 1.) A home that contains high quality materials skillfully installed with good workmanship and no defects.
 - 2.) A home that meets buyer's needs and desires.
 - 3.) A home that is sturdy, durable, and solid.
 - 4.) A home in which all walls, floors, and ceilings are straight, square, and plumb.
 - 5.) A home that is "tight" and energy efficient.
 - 6.) A home that is well designed and planned.
 - 7.) A home that is attractive.
 - 8.) A home that is built in accordance with code requirements.
-

expectations of consumers, which modular home manufacturers and builders should strive to consistently meet and exceed. It is interesting to note that consumers' definitions of a high quality home are very similar to builders' definitions.

D. When asked about the amount of time it took from the placement of a sales order to moving in, consumers responded as follows:

Less than expected: 23%

About what expected: 65%

Longer than expected: 12%

E. When asked about the price of their homes, consumers responded as follows:

Less than expected: 23%

About what expected: 69%

Greater than expected: 8%

F. When asked whether they would give their recommendation to other consumers about purchasing the same home from the same manufacturer, consumers responded as follows:

Strongly recommend to buy: 58%

Recommend to buy: 31%

Indifferent: 11%

Recommend not to buy: 0%

Strongly recommend not to buy: 0%

Consumers' reasons for recommending purchasing modular homes were:

1. Quick, efficient construction.
2. Well constructed, high quality home for reasonable price.
3. Manufacturer's service.
4. More cost effective and deadlines are easily met.
5. High quality of materials used.
6. Attractive design; well-engineered.
7. Minimal number of problems and defects.
8. Built in factory and protected from weather. Higher grade of work done in factory since it is so closely managed.
9. Exceeded our expectations.

5.6 SUMMARY OF CONSUMER SURVEY

As indicated in Table 5.6, the manufacturers of this study met or exceeded consumers' expectations 83% of the time. This seems to be a respectable rate and is slightly higher than the rate at which builders' expectations were met or exceeded. This may be due to one of the following reasons:

1. Builders' expectations are higher than consumers' expectations.
2. Builders correct manufacturers' defects before consumers move into the homes.
3. Manufacturer C, who received the most favorable consumer survey responses, represented a larger portion of the consumer survey than the builder survey (since the consumer survey did not include manufacturer B consumers).

As in the builder survey, the remaining 17% of consumers whose expectations were not met indicated that there was room for improvement in meeting or exceeding consumers' expectations. Although consumer expectations were met or exceeded 83% of the time, they were exceeded only 5% of the time, which indicates that there is much room for improvement in exceeding consumers' expectations.

The categories in which consumers' expectations were best met and exceeded were: 1. Quality of Electrical Systems, 2.

Quality of Windows, and 3. Roof Quality. In these three categories, consumers' expectations were met or exceeded 93%, 92%, and 89% of the time, respectively. Quality of windows also ranked second in the builder survey.

The categories in which consumers' expectations were least met were: 1. Quality of Doors, 2. Quality of Floors, and 3. Quality of Interior Walls. Although these three categories received the lowest ratings, consumers' expectations were still met or exceeded 75%, 75%, and 78% of the time, respectively. Quality of doors also received the lowest rating in the builder survey. Improving quality in this area is as simple as using doors that consumers perceive as high quality doors. For example, quality of windows received a very high rating in both surveys, due to the use of Anderson windows, which received a great deal of praise from numerous consumers and builders.

CHAPTER 6

QUALITY ADVANTAGES/DISADVANTAGES OF MODULAR HOMES

6.1 INTRODUCTION

As a result of the controlled environment in which modular homes are built, the intense scrutiny they receive, and the extra structural features that are added to each home in order to withstand stresses introduced during lifting and transporting, modular homes offer a number of quality advantages to builders and homebuyers. Unfortunately, the average American consumer and builder are not aware of these advantages. These advantages, as well as several disadvantages, are listed within this chapter. These quality advantages and disadvantages were derived from direct observations, interviews with employees of the three participating manufacturing plants, interviews with builders, and builder and consumer surveys.

6.2 SPEED OF DELIVERY

A major advantage that modular homes present to builders and consumers is the speed at which they can be delivered and made ready for move-in. The time span from a consumer or builder signing a design/purchase order to consumer move-in is typically around 90 days and can be as short as 60 days. This time span, however, can vary a great deal depending on the following factors:

1. Builder experience/familiarity with the setting process.
2. Builder planning/scheduling effort.
3. Complexity of design.
4. Size of home (number of modules).
5. Efficiency of manufacturing process.
6. Distance home is to be shipped.

The writer feels that a builder who takes the time to clearly understand the manufacturing, field setting, and finishing processes will be extremely pleased with how quickly a modular home can be manufactured, erected, and made ready for sale. Likewise, consumers who take the time to select a reputable builder and manufacturer will be extremely pleased with how quickly they can move into their new home. This quick turn-around time will also present builders and consumers with the advantage of reduced finance costs resulting from a shorter construction period. Builders can also rely on manufacturers'

promised delivery dates, which takes a good deal of the guesswork out of construction scheduling.

6.3 COST ADVANTAGES

It is generally accepted that a modular home can be built and completed with a five to ten percent cost savings over a stick built home of the exact same design, at the same location [4]. This amount will vary depending on the following factors:

1. Efficiency/overhead costs of manufacturer.
2. Degree of customization of home.
3. Distance that home is shipped.
4. Efficiency/overhead costs of the builder.

These cost savings are primarily an advantage to builders, in most cases, since they are typically the party that purchases the home from the manufacturer. Homebuyers may or may not experience all, or even part of these cost savings, depending on whether or not they purchase their home directly from the manufacturer, or what percentage of the savings are passed on to them from the builder.

Another cost advantage that should be very appealing to builders and homebuyers is that once a price is agreed on with a manufacturer, that price will remain firm unless the consumer requests a change order or modification. This takes a great deal of the guess work and worry out of the construction process since

hard costs quoted by the manufacturer can be relied upon.

6.4 EXTRA STRUCTURAL STABILITY

In order to strengthen and stiffen modular homes for transportation and lifting, extra structural features are added to modular homes. Some of these features are commonly added by all manufacturers and some manufacturers add more, or different, structural features than others.

The following extra structural features, for example, were added by all 3 manufacturers in this study:

1. Perimeter floor members (joists and headers) are doubled-up.
2. Wall studs are strapped to floor systems (in addition to nailing).
3. Roof systems are strapped to wall systems (in addition to nailing).
4. Floor sheathing, roof sheathing, and wallboard are glued to studs and joists (in addition to nailing).
5. Framing jigs are used to build floors, walls, ceilings, and roof systems in order to ensure squareness of members. This practice also minimizes bows and bulges and increases the tightness of homes. It must be noted, however, that the builder survey indicated that not all builders' expectations were met in this area.

Other structural extras that were added by either one or two of the manufacturers in the study are:

6. Corner studs are lag-bolted to increase strength and rigidity.
7. Corner studs are strapped around corners.
8. Exterior wall sheathing is strapped around corners.
9. Fastener plates are used on the top plates at all wall intersections.
10. Screws are used for all wallboard to provide extra pullout resistance.
11. Door and window headers are strapped to studs with metal plates.
12. A double ceiling/floor system is used between the first and second floors in order to increase the rigidity of separate modules. This increases the stiffness of the house and provides a 5 inch chase between floors which acts as a sound attenuation barrier and minimizes drilling of structural members to accommodate utility runs.
13. Drywall joints are reinforced on their back sides with joint compound and drywall or plywood plates.
14. Rigid waferboard, oriented strand board, or plywood is used for exterior wall sheathing to minimize racking and twisting of walls.
15. Wall studs at exterior corners receive hurricane

blocking.

Builders and consumers interested in purchasing modular homes are encouraged to investigate the extra structural features offered by various manufacturers.

6.5 MULTI-LEVEL INSPECTIONS

An extremely valuable, yet often overlooked advantage that modular homes offer is the intensity with which they are scrutinized at each step of the manufacturing process. They are examined and inspected by many individuals, both internal and external to the manufacturers. These multi-level inspections occur as follows:

1. The first inspection that occurs in the construction of modular homes is upon receipt of materials at the manufacturing plant. All materials are inspected for defects and conformance with specifications before they are introduced into the production line.
2. The next inspection occurs at the line worker level. Line workers ensure that they have the proper materials to build modules in accordance with production drawings. Line workers also ensure that they are performing their individual work tasks in accordance with designs.
3. Above the line worker level, foremen inspect modules to ensure that workers under their jurisdiction are building

modules in accordance with designs, codes, and specifications.

4. Modules are inspected between work stations as they are moved down the production line. Stations receiving modules inspect them to ensure that they meet the requirements necessary to perform their work properly. In some companies, modules are inspected before a station passes them down line to ensure that the next station is receiving modules that meet their requirements.
5. Production or area supervisors also inspect modules to ensure their conformance with designs, codes, and specifications.
6. Plant Quality Control Inspectors also inspect modules along all points of the production line to ensure their conformance with designs, codes, and specifications.
7. Third party inspectors who are certified by various states also inspect every home to ensure compliance with various state and national building, electrical, and plumbing codes. (It must be noted, however, that two of the builders surveyed experienced plumbing or electric code violations.)
8. State inspectors occasionally visit manufacturing plants to ensure compliance with state codes.
9. Builders inspect modules once they are delivered to the construction site for compliance with design drawings and

codes.

10. Local building code officials occasionally inspect modules once they arrive on site to ensure compliance with local and other applicable codes. They also inspect completed homes for code compliance prior to issuing occupancy permits.

Although these multiple levels of inspection do not guarantee a defect-free home, modular homebuyers should feel quite confident that every component of their home, including structural components and utilities systems hidden inside of walls, have been checked numerous times for compliance with various code and design requirements.

6.6 ADDITIONAL QUALITY ADVANTAGES

In addition to the previously listed quality advantages, the three modular home manufacturers of this study offer a number of cosmetic and miscellaneous advantages. These advantages are as follows:

1. Ceiling board is fastened to ceiling joists with spray-foam adhesive. This material tightly bonds the ceiling board to the joists without the use of nails or screws, thereby eliminating the chance for nail pops.
2. Home modules are constructed indoors with no exposure to rain, snow, or extreme temperature and humidity swings.

This greatly reduces the chance of buckling, warping, and cupping of building components as well as nail pops.

3. Floor sheathing and ceiling board are used in widths equal to module widths. This minimizes the number of joints in floors and ceilings.
4. Sheet vinyl flooring extends beneath stud walls. This eliminates the possibility of curling at edges and ensures the tightness of the vinyl flooring.
5. Manufacturers are extremely flexible in their designs. The three manufacturers in this study all have a standard set of designs, but routinely modify those standard designs or create new designs in order to meet the requirements of their builders and consumers.
6. Quality of workmanship on the production line is extremely high. Line workers become very proficient in their individual work tasks because of the repetitive nature of the manufacturing process. It must be noted, however, that the builder and consumer surveys indicated that builders' and consumers' expectations were not always met in the area of quality of workmanship of wall and ceiling finishes.
7. Paint is typically applied with airless spray-applicators which produce a very uniform finish.
8. Wall, floor, ceiling, and roof components fit tightly together, exterior sheathing joints are caulked, and wall

penetrations are sealed with spray-foam. All of these features increase the thermal efficiency of modular homes. It should be noted that one consumer complained about the high cost of electric heat.

9. Overhead/project control costs and administrative burden are greatly reduced due to the minimal amount of work in the field and the minimal number of subcontractors.
10. The risk of vandalism and theft in the field are greatly reduced since the homes can typically be closed in and locked the same day they are delivered.

6.7 DISADVANTAGES

Builders and consumers must also be aware of the disadvantages associated with modular homes. These disadvantages are as follows:

1. Transportation of modules nearly always results in some cracking of ceilings, and walls above doors and windows. These cracks, however, are typically repaired prior to consumer move-in.
2. One of the participating manufacturers did not inspect the builders' foundations prior to delivering modules. Improperly constructed foundations could lead to a number of problems such as cracks in walls and ceilings, windows and doors sticking, delayed construction schedule, and

extended overhead costs while corrections are being made.

3. Communication between manufacturers and homebuyers is minimal. Consumers must rely on the builder, acting as an intermediary, to communicate their needs and requirements to the manufacturer. Once consumer requirements are passed to the manufacturer, consumers must rely on the manufacturer to properly communicate their requirements through several departments. Thus, consumers have minimal control over ensuring that their requirements are met.
4. Depending on the manufacturer/builder relationship, consumers may find themselves in the middle of a responsibility contest between the builder and the manufacturer when problems or discrepancies arise in their homes. However, all three manufacturers in this study typically performed any such disputed repairs in order to ensure customer satisfaction.

6.8 SUMMARY

The quality advantages and disadvantages listed in this chapter were derived from direct observations, interviews with employees of the three participating manufacturing plants, interviews with builders, and builder and consumer surveys. Accordingly, these lists are not all-inclusive and variations

will occur among various manufacturers. It can be concluded, however, that the quality advantages of modular homes outweigh the potential disadvantages depending, of course, on the quality orientation of individual manufacturers and builders.

CHAPTER 7

SUMMARY/CONCLUSIONS/RECOMMENDATIONS

7.1 SUMMARY

This report has provided an introductory analysis of quality in the modular housing industry. The study concentrated on three separate modular home manufacturers in an attempt to identify the quality advantages and disadvantages of modular homes, and to support the following three assertions about the quality of modular housing:

1. The controlled environment of a modular housing plant provides the optimum setting for controlling product quality.
2. Modular housing manufacturers are taking advantage of this optimum setting by employing modern quality management practices to rigidly control the quality of their product.
3. Builders and consumers are highly satisfied with the quality of the modular homes they receive from

manufacturers.

An extensive literature review was conducted in the areas of: (1) modern quality management concepts and (2) modular housing. The quality management review provided the writer with a sound understanding of modern quality management practices and principles. The modular housing literature review provided the writer with an understanding of the current state of information about the modular housing industry.

An Ideal Quality Management Plan was developed by consolidating the modern quality management practices and concepts derived from the literature search and tailoring them to fit the modular housing process. The ideal plan was then used to evaluate the degree to which modular housing manufacturers are employing modern quality management techniques.

In-Plant Quality Reviews were conducted in the three modular manufacturing plants in order to:

- Identify the quality advantages of modular homes.
- Determine whether the controlled environment of a modular housing plant provides the optimum setting for controlling product quality.
- Determine the degree of modern quality management techniques being used by manufacturers in the industry.

A Builder and a Consumer Survey were conducted by developing a questionnaire which was distributed to builders and consumers (home buyers) of the three manufacturers in order to: (1) measure

their degree of satisfaction with the quality of the manufacturers' homes, and (2) to establish a builder/consumer definition of quality as it applies to modular homes.

7.2 CONCLUSIONS - MODULAR MANUFACTURING PROCESS

It is the opinion of the writer that the following factors make a modular manufacturing plant an ideal setting for producing high quality homes:

- 1) Homes are protected from wind, rain, snow, and extreme swings in temperature and humidity during construction. This greatly reduces the chance of water damage and wind damage during construction, and minimizes the possibility of warping, buckling, twisting, and cupping of members.
- 2) The intensity with which modular homes are scrutinized at every step of production by both in-plant and third party inspectors, virtually guarantees that they will be built in accordance with plans, specifications, and applicable building codes. A detailed description of the multi-level inspections modular homes receive is provided in Chapter 6.
- 3) Modular home manufacturers have dedicated quality control departments who constantly monitor the quality of every home produced.
- 4) The repetitive nature of work performed on the production line allows workers to become highly proficient in

performing their work tasks.

It cannot be concluded, however that all modular manufacturers produce high quality homes. Those manufacturers who place the highest amount of importance on meeting and exceeding consumer expectations and needs will best be able to utilize the advantages offered by a manufacturing plant environment to consistently and economically produce homes that are recognized as high quality homes. The writer feels that consumers who carefully select both a reputable manufacturer and a reputable builder can feel quite comfortable that they will be purchasing a high quality home.

7.3 CONCLUSIONS - MODERN QUALITY MANAGEMENT PRACTICES

The writer found that all three manufacturers of the study are employing a majority (70%, 84%, and 89%) of the line items of the ideal quality management plan listed in Appendix B. It cannot be concluded, however, from this small sample that this represents the quality management efforts of the industry as a whole. This may, however, be an indication that the modular manufacturing process fosters a strong focus on managing the quality of the product.

It is interesting to note that the results of this study may indicate that there is a correlation between the level of a modular manufacturer's quality management effort and the degree

TABLE 7.1 - COMPARISON OF QUALITY MANAGEMENT EFFORT AND CUSTOMER SATISFACTION

	<u>Quality Management Rating</u>	<u>Met or Exceeded Builder Expectations</u>	<u>Met or Exceeded Consumer Expectations</u>
Manufacturer A	70%	52%	75%
Manufacturer B	84%	71%	-
Manufacturer C	89%	83%	90%

of builder and consumer satisfaction. Table 7.1 compares the participating manufacturers' quality management effort ratings (from Table 4.1) with the degree to which each met or exceeded builder and consumer expectations (from Tables 5.3 and 5.6). Table 7.1 indicates that higher levels of effort in quality management (conformance with the ideal quality management plan in Appendix B) result in a higher degree of builder and consumer satisfaction.

7.4 CONCLUSIONS - BUILDER SURVEY

As indicated in Table 5.3 in Chapter 5, the manufacturers in this study met or exceeded builder expectations 75% of the time. This seems to be a respectable rate, although it cannot be compared with general industry statistics since no similar survey has been previously conducted. There are, however, the remaining 25% of builders' expectations that were not met, which indicates

there is room for improvement in meeting or exceeding builders expectations. It is interesting to note that although builders' expectations were met or exceeded 75% of the time, their expectations were exceeded only 7% of the time. This figure indicates that there is much room for improvement in exceeding builders' expectations. Accordingly, a quality conscious manufacturer could gain a competitive advantage by finding ways to consistently exceed builder expectations.

The categories in which builders' expectations were best met were: 1. Quality of Manufacturer's Service; 2. Quality of Windows; and 3. Quality of Floors. In these three categories, builders' expectations were met or exceeded 91%, 87%, and 82% of the time, respectively. The high quality rating for windows indicates that a company can easily improve its quality image by using high quality manufactured products such as windows, doors, kitchen cabinets, etc.

The categories in which builders' expectations were least met were: 1. Quality of Doors; 2. General Quality of modules (i.e. fit and compatibility); and 3. Quality of Plumbing and Electrical Systems. Although these three categories received the lowest ratings, builders' expectations were still met or exceeded in each 66%, 69%, and 70% of the time, respectively.

General conclusions about the industry as a whole cannot be drawn from this data, but the data does indicate that quality within the industry is not yet "perfect" and there is some room

for improvement. This survey could be expanded to encompass a wider cross section of the industry. General conclusions about industry as a whole can be drawn from such an expanded study. The questionnaire used for this survey can also be used by individual manufacturers to assess how well they are meeting or exceeding the expectations of their builders.

7.5 CONCLUSIONS - CONSUMER SURVEY

As indicated in Table 5.6 in Chapter 5, the manufacturers in this study met or exceeded consumers' expectations 83% of the time. This seems to be a respectable rate and is slightly higher than the rate at which builders' expectations were met or exceeded. This may be due to one of the following reasons:

1. Builders' expectations are higher than consumers' expectations.
2. Builders correct manufacturers' defects before consumers move in to homes.
3. Manufacturer C, who received the most favorable consumer survey responses, represented a larger portion of the consumer survey than in the builder survey (since the consumer survey did not include manufacturer B consumers).

As in the builder survey, the remaining 17% of consumers whose expectations were not met indicate that there is room for

improvement in meeting or exceeding consumers' expectations. Although consumer expectations were met or exceeded 83% of the time, they were exceeded only 5% of the time, which indicates that there is much room for improvement in exceeding consumers' expectations.

The categories in which consumers' expectations were best met and exceeded were: 1. Quality of Electrical Systems; 2. Quality of Windows; and 3. Roof Quality. In these three categories, consumers' expectations were met or exceeded 93%, 92%, and 89% of the time, respectively. It should be noted that quality of windows also ranked second in the builder survey.

The categories in which consumers' expectations were least met were: 1. Quality of Doors; 2. Quality of floors; and 3. Quality of Interior Walls. Quality of doors also received the lowest rating in the builder survey. Although these three categories received the lowest ratings, consumers' expectations were still met or exceeded 75%, 75%, and 78% of the time, respectively.

This survey, like the builder survey, could be expanded to encompass a wider cross-section of the industry. General conclusions about the industry as a whole could be drawn from such an expanded study. The questionnaire used for this survey can also be used by individual modular manufacturers and other systems-built manufacturers to assess how well they are meeting or exceeding the expectations of their consumers.

7.6 CONCLUSIONS - QUALITY ADVANTAGES/DISADVANTAGES

The writer found that modular homes offer numerous quality advantages, as well as several disadvantages. These advantages and disadvantages were identified by direct observation, interviews with employees of the three participating manufacturers, interviews with builders, and builder and consumer surveys. The quality advantages have been grouped into the following categories:

- 1) Speed of Delivery
- 2) Cost Advantages
- 3) Structural Advantages
- 4) Multi-Level Inspection Advantages
- 5) Additional Miscellaneous Advantages

Detailed lists of the advantages and disadvantages are provided in Chapter 6. It must be noted that these lists are not all-inclusive and variations will occur among various manufacturers. It can be concluded, however, that the quality advantages of modular homes far outweigh the potential disadvantages depending, of course, on the quality orientation of individual manufacturers and builders.

7.7 RECOMMENDATIONS FOR FUTURE RESEARCH

This study has resulted in a favorable assessment of quality

in the modular housing industry. It is the opinion of the writer that the industry as a whole needs to actively promote the quality of modular homes and educate American consumers and builders about the modular manufacturing process and the advantages that it offers to both. This report has provided a limited base upon which claims about the quality advantages of modular homes can be founded. The three manufacturers who participated in this study could rightfully make such claims about their homes, but the industry as a whole would need to base such claims on a wider-scaled study that would include a representative sample of industry manufacturers, builders, and consumers. The writer feels that it would be to the industry's advantage to perform such a study, using the questionnaires and procedures developed in this report as a basis.

The writer's recommendations for future research are:

- 1) Determine the reason or reasons why most American consumers consider modular homes a low quality, undesirable housing alternative.
- 2) Use the same techniques as this report (quality management plan rating system, builder and consumer questionnaires, and in-plant observations) to analyze the quality management efforts of enough manufacturers to constitute a representative measure of quality in the

industry as a whole.

3) Specifically identify the "costs of poor quality" for one or more manufacturers in order to quantify the potential cost savings that can be realized by employing all of the elements of the ideal quality management plan in Appendix B.

4) Use the expanded study suggested in (2) above, to better determine if there is a correlation between the level of manufacturers' quality management efforts and the degree of builder and consumer satisfaction with the quality of their homes. Such a determination would prove or disprove the effectiveness of using modern quality management techniques to ensure that customer needs and expectations are met or exceeded.

5) Identify methods of exceeding builder and consumer expectations in order to make modular homes more appealing to both.

6) Perform a similar quality analysis which concentrates on the field portion of the modular manufacturing process (setting and finishing modules). Such a study would complement this study, which has focused primarily on the in-plant portion of the modular manufacturing process, and

would also allow the industry to assess the quality implications of its builder/manufacturer relationships.

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APPENDIX A

GLOSSARY

GLOSSARY

consumer: the end user or buyer of a product; e.g. homebuyer

customer: person or entity who receives a product or service;

e.g. builder is the customer of the manufacturer, and
homebuyer is the customer of the builder

immediate customer: next person or entity down-line to receive
product or service in the manufacturing process; e.g.
the wall setting station is the immediate customer of
the wall framing station

modular manufacturing process: process which includes ordering,
designing, manufacturing, erecting, finishing, and
purchasing modular home, and service after sale;
includes consumer, manufacturer's personnel, and
builder's personnel

quality: consistently meeting and exceeding consumer's needs and
expectations, at an affordable price, with no defects
over the life of the product

quality assurance: spot-checking the quality of process and
product, in order to ensure the effectiveness of
quality control efforts

quality audit: a diagnosis of the overall state of the quality
management efforts of a company [9]

quality control: the detection and elimination of product and
process defects at their root source

quality control plan: written plan which delineates the details

of each employee's responsibilities in controlling product quality within the manufacturing process, as well as defining conformance standards and inspection schedules

quality improvement: using modern quality management and quality control techniques to constantly improve product and process quality, with the ultimate goal of doing everything correctly the first time

quality management: management style which incorporates all of the basic elements of quality into all aspects of running a business

quality policy: clear, concise statement which delineates a company's long term quality goals; differs from a quality control plan in that it does not address the details of the role of each employee's individual responsibility in controlling product quality within the manufacturing process - rather, it delineates the global quality issues and broadly delineates the responsibilities that every member of a company must assume

root cause: the root source of a problem or defect, which, if eliminated, will prevent the re-occurrence of the problem or defect

TRIPROL: abbreviation for the "triple role" that each employee of a company plays as: customer, processor, and supplier

APPENDIX B

IDEAL QUALITY MANAGEMENT PLAN FOR A TYPICAL MODULAR HOUSING
MANUFACTURER

This Appendix presents an outline of an ideal quality management plan for a typical modular housing manufacturer. The outline follows the list of the basic elements of modern quality management that were presented in Chapter 2. These elements were derived from references [1], [5], [6], [7], [8], [9], and [10]. Since the outline has been developed for a "typical" manufacturer, the elements of the plan are listed in a generic fashion. The outline should be modified to fit individual manufacturers by adding more detailed information that is pertinent to the specific operations of the individual manufacturers. This outline can also be used as a gauge to measure the degree to which individual modular manufacturers are employing modern quality management techniques. With minor modifications, this outline can also be used by all Systems Built Housing manufacturers.

I. THE ROLE OF MANAGEMENT

- A. Sincere commitment to quality.
- B. Thorough understanding of quality management concepts.
- C. Active participation in quality management system.
- D. Understands the true function of the quality department.
- E. Primary focus is not on short-term profits.
- F. Primary focus is on long-term profit and reputation for quality of homes.
- G. Dedicated to constantly improving the quality of homes.
- H. Understands that it will take several years to fine tune an effective quality management system.
- I. Has established standard definitions for quality and quality-related terms in order to avoid confusion. Knows and disseminates to all employees the elements that make a home a "quality" home.
- J. Sound quality policy has been developed and is understood by all employees of the company. Management actively supports the policy and updates it at regular intervals.
- K. Understands human error and the natural variability of modular home building process.
- L. Does not place blame on individuals.
- M. Fosters, and takes seriously, suggestions from subordinates.
- N. Provides workers with proper tools and equipment that allow them to perform their work in the most consistent and efficient manner possible, e.g. pneumatic nail guns, powered screw guns, paint spray applications, jigs, jib cranes, computer aided design systems for the engineering department, etc.
- O. Provides all employees with proper training.
- P. Ensures that internal and external feedback loops are open and being used.
- Q. Holds regular meetings to discuss/improve quality management procedures.
- R. Strives to retain workers and understands that the company's employees are its most important long-term asset. Realizes that long-term quality improvement requires trained workers who are familiar with the details of the company's quality management system and manufacturing process.
- S. Fosters a team approach to quality management .
- T. Participates regularly in quality audits and ensures that audit findings are acted upon.
- U. Thoroughly understands the needs and expectations of builders who erect the company's homes and the consumers who buy them.
- V. Ensures that builder and consumer expectations and needs are considered in every part of the manufacturing process,

- from design to customer service after sale.
- W. Ensures that every individual within the company understands the importance of meeting and exceeding builder and consumer expectations and needs.

II. THE QUALITY POLICY

- A. Clearly states the company's quality goals.
- B. Is concise.
- C. Is well understood and adhered to by all employees.
- D. Is actively supported by top management.
- E. Clearly defines what constitutes a quality home.
- F. Focuses on long-term quality goals.

III. THE ROLE OF THE WORKER

- A. Performs all tasks in accordance with quality policy.
- B. Contributes to the team effort of producing top quality homes.
- C. Understands each aspect of his/her TRIPROL function as customer, processor, and supplier.
- D. Clearly understands how his/her function affects the rest of the manufacturing process.
- E. Is able to decide whether personal work meets the requirements of the production drawings, specifications, and company standards.
- F. Understands how his/her personal task adds to the ability to meet and exceed internal and external customer needs and expectations.
- G. Looks for ways to improve personal task in order to build quality homes more consistently and efficiently.
- H. Understands and believes in the quality policy and how the quality policy relates to building quality homes.
- I. Understands builder and consumer needs and expectations and constantly strives to meet and exceed them.
- J. Understands the overall building process and how each department and workstation contributes to the quality of homes.
- K. Proficient in the work skills needed to perform tasks consistently and efficiently.
- L. Understands the importance of feedback loops and uses them freely.
- M. Not intimidated by management.
- N. Understands the role of the quality department and does not regard the quality department as a "watchdog."
- O. Feels free to, and understands requirement to, provide input into the design of homes.
- P. Believes that management cares about his/her ideas.
- Q. Understands the goals of quality inspections and audits.

- R. Does not fear quality audits - accepts them as a means of finding ways to improve process and product quality.

IV. DESIGNING FOR QUALITY

- A. All employees of the design department are intimately familiar with builder and consumer needs and expectations.
- B. The design department knows how to meet and exceed internal and external customer needs and expectations.
- C. The design department constantly solicits feedback from manufacturing line.
- D. The design department is part of all company feedback loops.
- E. The design department consistently ensures that quality is built-in to the design of each home.
- F. Production drawings are clear and easily understood.
- G. The design department constantly strives to improve the quality of the home designs.
- H. The design department constantly strives to improve the quality of the production drawings.
- I. The design department consistently ensures the constructability of home designs.
- J. Top quality materials are specified.
- K. The design department works very closely with the sales and marketing department to ensure that builder and consumer needs and expectations are met and exceeded in all home designs.
- L. Designs intentionally minimize scrap and waste.
- M. Designs consistently meet all applicable building codes.
- N. Use of computerized design and take-off systems for minimization of errors and ease of updating designs.

V. THE ROLE OF THE SALES AND MARKETING DEPARTMENT

- A. Every employee in this department is intimately familiar with the needs and expectations of builders and consumers.
- B. Understands how to meet and exceed builder and consumer needs and expectations.
- C. Consistently performs market surveys to stay ahead of builder and consumer expectations and needs.
- D. Consistently solicits builder and consumer feedback in order to identify the good and bad points of the homes being built.
- E. Ensures company-wide dissemination of information about builder and consumer needs, expectations, and feedback.
- F. Knows that the "consumer is king." [7]

VI. QUALITY OF MATERIALS

- A. The materials that are used consistently meet and exceed the needs and expectations of consumers, builders, and the company. They are free of defects, meet code requirements, and are affordable.
- B. The choice of materials suppliers is not based on price alone.
- C. Limit the number of suppliers (ideally only one) for each type of material used in the home manufacturing process.
- D. Educate suppliers about the quality policy and requirements of the company.
- E. Work with suppliers and provide feedback for constantly improving the quality of materials.
- F. Make suppliers a part of the "quality team."
- G. Strive to eliminate incoming defective materials.
- H. Use feedback loops to identify materials that meet all internal and external needs consistently, at an affordable price, while also contributing to the ease of manufacture.

VII. QUALITY OF THE MANUFACTURING PROCESS

- A. Process is designed to consistently deliver quality homes without generating scrap or rework, and without relying on massive checks and inspections.
- B. The manufacturing system is in a constant state of improvement.
- C. Employee suggestions are solicited and used.
- D. Use of tools and equipment which allow workers to perform their tasks consistently and efficiently (ex: nail guns, screw guns, jigs, jib cranes, paint spray applicators, etc.).
- E. Minimum amount of down-time.
- F. Easy and early detection of discrepancies is possible.
- G. Focus is on quality and conformance goals - not quantity goals.
- H. Identify parts of the process that are critical to quality and focus attention on those areas.

VIII. QUALITY IMPROVEMENT

- A. Company-wide goal to design and build every part of every home right the first time.
- B. Feedback loops (internal and external) are used as sources of ideas for improving the quality of homes.

IX. FEEDBACK LOOPS

- A. Feedback occurs at all levels within company.

- B. Feedback is constantly sought from builders, consumers, and prospective consumers.
- C. Feedback loops are used to trace all discrepancies to their root source.
- D. Feedback is provided to suppliers and builders.

X. TRAINING

- A. All employees receive training regarding (1) quality concepts, (2) quality policy and the goals of company, (3) individual work tasks, (4) overall manufacturing process (from market research to customer service after sale of homes), (5) the team approach to quality, and (6) applicable codes.
- B. Training is continuous (not a one-shot deal).
- C. All new employees are thoroughly trained before starting work.
- D. Workers are all trained to make quality conformance decisions.
- E. Management attends all training sessions first.
- F. The curriculum is designed and regularly updated by management and the quality department.

XI. QUALITY AUDITS

- A. Quality audits are regularly performed in each department and at each work station on the line.
- B. The results of audits are used to improve the quality management system and the manufacturing process.
- C. Audit teams include representatives of all departments and work stations at some point in time.
- D. Audits are not feared by employees.

XII. QUALITY CONTROL

- A. Inspection checklists are generated directly from production drawings and the applicable specifications and codes.
- B. Workers are trained so they are capable of making quality conformance decisions.
- C. Workers are allowed to make conformance decisions.
- D. Inspection results are fed into a database for analysis by management.
- E. Feedback loops are used to trace discrepancies to root sources and the root sources of problems are corrected.
- F. Company uses the quality control plan that is required by codes as an active quality management tool (not just a dummy plan).

- G. Inspections occur at all stations and at the end product.
- H. Findings of third party inspections are fed into the quality improvement system.
- I. Employees do not believe that defects are "normal."
- J. Inspections are standardized - standard forms are used.
- K. Pass/fail criteria is well defined at each step of the building process.

XIII. ROLE OF THE QUALITY DEPARTMENT

- A. It does not play a "watchdog" role and is not perceived by workers as a "watchdog."
- B. It monitors, orchestrates, and updates the company's overall quality management system.
- C. It is not feared or resented by line workers.
- D. It is regarded by all as a source of knowledge about how to best guarantee quality products.
- E. It establishes good working relationship with third-party inspectors.
- F. It presents top management with cost reports of cost savings due to the company's quality management efforts.
- G. It assists management in planning and coordinating the company's training curriculum, quality audits, quality control inspections, and quality policy.
- H. It monitors the progress of quality improvement.
- I. It monitors the state of all of the basic elements of the quality management system.
- J. It does not perform pass/fail quality control inspections (workers should do this at their work stations), but rather performs spot-checks to ensure the effectiveness of worker assessments.

XIV. COSTS OF POOR QUALITY

- A. Management understands the elements of costs of poor quality.
- B. Costs of poor quality are clearly identified.
- C. The costs are used as a measuring stick to gauge the progress of the company's quality effort.

XV. BUILDERS

- A. Builders are trained in the concepts of the company's quality policy.
- B. Builders realize the importance of meeting and exceeding consumer needs and expectations.
- C. Builders understand the quality requirements for foundations.

- D. The company should inspect builders' foundations and finish work to ensure the quality of the completed home.
- E. Builders actively participate in the manufacturer-builder-customer feedback loop.

APPENDIX C
BUILDER SURVEY QUESTIONNAIRE

GENERAL INFORMATION:

1.) How many modular homes have you built in the past calendar year? _____

2.) How many modular homes have you built in each of the following price ranges in the past year? (price to consumer)

<u>Price Range</u>	<u># of Homes</u>
\$30,000 - \$50,000	_____
\$50,000 - \$70,000	_____
\$70,000 - \$90,000	_____
\$90,000 - \$110,000	_____
\$110,000 - \$150,000	_____
over \$150,000	_____

3.) Average size of home (square feet) _____

QUALITY OF MODULAR MANUFACTURER'S SERVICE

4.) In general did the manufacturer deliver modules

- ☐ before promised date
- ☐ on promised date
- ☐ after promised date

5.) In general, the manufacturer's responsiveness to service calls or questions from the time of design to the time of final service was

- ☐ better than you expected
- ☐ about what you expected
- ☐ worse than you expected

6.) In general, the number of design errors was

- ☐ less than you expected
- ☐ about what you expected
- ☐ greater than you expected

7.) In general, the manufacturer's responsiveness to special design requests was

() better than you expected

() about what you expected

() worse than you expected

8.) Based on the above criteria, how would you rate the overall quality of the service provided by the manufacturer?

Poor

Fair

Good

Excellent

Additional Comments: _____

GENERAL QUALITY OF MODULES

<u>Module Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
9.) Squareness of Walls	() All walls square	()
	() Most walls square	()
	() Most walls not square	()
10.) Module Dimensions	() All dimensions correct	()
	() Most dimensions correct	()
	() Most dimensions incorrect	()
11.) Compatibility with Foundation	() All modules seat correctly on foundation	()
	() Most modules seat correctly on foundation	()
	() Most modules don't seat correctly on foundation	()
12.) Compatibility with other modules	() All modules fit together correctly	()
	() Most modules fit together correctly	()
	() Most modules don't fit together correctly	()

- 13.) Ship Loose (☐) All materials included (☐)
Material and correct
- (☐) Most materials included (☐)
 and correct
- (☐) Most materials not included (☐)
 or incorrect

14.) Based on the above criteria, how would you rate the overall quality of the manufacturer's home modules?

Poor Fair Good Excellent

Additional Comments: _____

QUALITY OF FLOORS

<u>Floor Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
15.) Squeaks	☐ No squeaky areas	☐
	☐ One or two squeaky areas	☐
	☐ Several squeaky areas	☐
16.) Noticeable	☐ None	☐
Subfloor Joints	☐ One or two	☐
	☐ Several	☐
17.) Subfloor Rigidity	☐ No bounce in floors	☐
	☐ Slight bounce in floors	☐
	☐ Substantial bounce in floors	☐
18.) Visible Carpet	☐ None	☐
Seams	☐ One or two	☐
	☐ Several	☐
19.) Bumps/Bulges In	☐ None	☐
Carpet or Other	☐ One or two	☐
Floor Finishes	☐ Several	☐

- | | | |
|-----------------------------------|--|--|
| 20.) Carpet Snags/
Tears | ☐ None
☐ One or two
☐ Several | ☐
☐
☐ |
| 21.) Carpet stains | ☐ None
☐ One or two
☐ Several | ☐
☐
☐ |
| 22.) Cuts/Tears in
Sheet Vinyl | ☐ None
☐ One or two
☐ Several | ☐
☐
☐ |
| 23.) Sheet Vinyl
Seams | ☐ Invisible or none
☐ Difficult to detect
☐ Very noticeable | ☐
☐
☐ |

24.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's floors?

Poor Fair Good Excellent

Additional Comments: _____

QUALITY OF INTERIOR WALLS

<u>Interior Wall Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
25.) Cracks	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
26.) Nail Pops	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
27.) Noticeable Wallboard	☐ None	☐
Joints	☐ One or two	☐
	☐ Several	☐

- | | | |
|------------------------|--|--------------------------|
| 28.) Bulges in Walls | ☐ None | ☐ |
| | ☐ One or two | ☐ |
| | ☐ Several | ☐ |
| | | |
| 29.) Evenness of Paint | ☐ No shadows | ☐ |
| | ☐ One or two shadows | ☐ |
| | ☐ Several shadows | ☐ |
| | | |
| 30.) Paint Drips/Runs | ☐ None | ☐ |
| | ☐ One or two per room | ☐ |
| | ☐ Several | ☐ |
| | | |
| 31.) Ease of Matching | ☐ Very easy | ☐ |
| Touch-Up Paint | ☐ Somewhat difficult | ☐ |
| Texture | ☐ Very difficult | ☐ |
| | | |
| 32.) Corners Straight | ☐ All straight & even | ☐ |
| and Even | ☐ Mostly straight & even | ☐ |
| | ☐ Mostly crooked & uneven | ☐ |
| | | |
| 33.) Wallpaper | ☐ No gaps | ☐ |
| (if applicable) | ☐ One or two gaps | ☐ |
| | ☐ Several gaps | ☐ |

- ☐ Pattern matches at all seams ☐
- ☐ Pattern matches at most seams ☐
- ☐ Pattern doesn't match at most seams ☐

34.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's interior walls?

Poor

Fair

Good

Excellent

Additional Comments: _____

QUALITY OF CEILINGS

<u>Ceiling Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
35.) Cracks	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
36.) Nail Pops	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
37.) Noticeable Joints	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
38.) Evenness of Paint	☐ No shadows	☐
	☐ One or two shadows	☐
	☐ Several shadows	☐
39.) Corners Straight	☐ All straight & even	☐
and Even	☐ Mostly straight & even	☐
	☐ Mostly crooked & uneven	☐

40.) Sags/Bulges ☐ None ☐
 ☐ One or two ☐
 ☐ Several ☐

41.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's ceilings?

Poor Fair Good Excellent

Additional Comments: _____

QUALITY OF EXTERIOR WALLS

<u>Exterior Wall Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
-------------------------------	--------------------------	-----------------------------

42.) Ease of Matching	☐ Very easy	☐
Siding Pattern	☐ Somewhat difficult	☐
Across Modules	☐ Very difficult	☐

- | | | |
|----------------------|-------------------------------------|--------------------------|
| 43.) Buckles/Gaps in | ☐ None | ☐ |
| Siding | ☐ One or two | ☐ |
| | ☐ Several | ☐ |
| | | |
| 44.) Leaks Through | ☐ None | ☐ |
| Walls | ☐ One or two | ☐ |
| | ☐ Several | ☐ |

45.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's exterior walls?

Poor Fair Good Excellent

Additional Comments: _____

ROOF QUALITY

<u>Roof Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
46.) Ease of Matching	☐ Very easy	☐
Shingle Pattern	☐ Somewhat Difficult	☐
	☐ Very Difficult	☐
47.) Torn/Broken	☐ None	☐
Shingles	☐ One or two	☐
	☐ Several	☐
48.) Shingle Tabs	☐ All	☐
Sealed	☐ Most	☐
	☐ Several	☐
	☐ None	☐
49.) Shingle Pattern	☐ Straight & even	☐
	☐ Slightly uneven	☐
	☐ Mostly uneven	☐
50.) Shingles Laying	☐ All	☐
Down Flat	☐ Most	☐
	☐ Few	☐

51.) Roof Bulges/Sags (☐) None (☐)
 (☐) One or two (☐)
 (☐) Several (☐)

52.) Roof Leaks (☐) None (☐)
 (☐) One or two (☐)
 (☐) Several (☐)

53.) Tilt-Up Roofs ☐ All ridgelines match properly ☐
 ☐ Most ridgelines match properly ☐
 ☐ Most ridgelines do not match
 properly

54.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's roofs?

Poor Fair Good Excellent

Additional Comments:_____

QUALITY OF WINDOWS

<u>Window Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
55.) Broken panes	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
56.) Leaking Windows	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
57.) Sticking Windows	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
58.) Properly Flashed	☐ All	☐
	☐ Most	☐
	☐ Several	☐

59.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's windows?

Poor

Fair

Good

Excellent

Additional Comments: _____

QUALITY OF DOORS

<u>Door Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
----------------------	--------------------------	-----------------------------

60.) Sticking Doors	☐ None	☐
	☐ One or two	☐
	☐ Several	☐

- 61.) Defective Door ☐ None ☐
 Hardware ☐ One or two items ☐
 ☐ Several items ☐
- 62.) Drafts Around ☐ None ☐
 Exterior Doors ☐ One or two ☐
 ☐ Several ☐
- 63.) Water Leaks Around ☐ None ☐
 Exterior Doors ☐ One or two ☐
 ☐ Several ☐

64.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's doors?

Poor Fair Good Excellent

Additional Comments: _____

QUALITY OF PLUMBING SYSTEM

<u>Plumbing Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
--------------------------	--------------------------	-----------------------------

65.) Code Violations	☐ None	☐
	☐ One or two	☐
	☐ Several	☐

66.) Discrepancies	☐ None	☐
From Plans	☐ One or two	☐
	☐ Several	☐

67.) Leaks at Faucets	☐ None	☐
and Appliances	☐ One or two	☐
	☐ Several	☐

68.) Leaks Within	☐ None	☐
System	☐ One or two	☐
	☐ Several	☐

69.) Broken Pipes/	☐ None	☐
Fittings	☐ One or two	☐
	☐ Several	☐

70.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's plumbing systems?

Poor

Fair

Good

Excellent

Additional Comments: _____

QUALITY OF ELECTRICAL SYSTEMS

<u>Electrical Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
----------------------------	--------------------------	-----------------------------

71.) Code Violations	☐ None	☐
----------------------	-------------------------------	--------------------------

	☐ One or two	☐
--	-------------------------------------	--------------------------

	☐ Several	☐
--	----------------------------------	--------------------------

72.) Discrepancies From	☐ None	☐
-------------------------	-------------------------------	--------------------------

Plans	☐ One or two	☐
-------	-------------------------------------	--------------------------

	☐ Several	☐
--	----------------------------------	--------------------------

- 73.) Faulty Lights/ Switches ☐ None ☐
 ☐ One or two ☐
 ☐ Several ☐
- 74.) Faulty Receptacles ☐ None ☐
 ☐ One or two ☐
 ☐ Several ☐
- 75.) Faulty Breakers ☐ None ☐
 in Panel Box ☐ One or two ☐
 ☐ Several ☐

76.) Based on the above criteria, how would you rate the overall quality of the modular manufacturer's electrical systems?

Poor Fair Good Excellent

Additional Comments: _____

GENERAL

77.) Is there any aspect of the modular manufacturer's homes that greatly exceeded your expectations or that you were extremely pleased with?_____

78.) Is there any aspect of the modular manufacturer's homes that fell far short of your expectations or that you are extremely disappointed with?_____

79.) In your own words, how do you define a high quality home?

80.) What would your recommendation be to another builder interested in building modular homes from the modular manufacturer?

- ☐ Strongly recommend to build
- ☐ Recommend to build
- ☐ Indifferent
- ☐ Recommend not to build
- ☐ Strongly recommend not to build

Reason: _____

81.) Which type of home do you prefer to build?

- ☐ Modular
- ☐ Stick-built

Reason: _____

APPENDIX D
CONSUMER SURVEY QUESTIONNAIRE

GENERAL INFORMATION

1.) Manufacturer of your home _____
(name & location)

2.) Builder of your home _____
(name & location)

3.) Price range of your home: ☐ \$30,000 - \$50,000
☐ \$50,000 - \$70,000
☐ \$70,000 - \$90,000
☐ \$90,000 - \$110,000
☐ \$110,000 - \$150,000
☐ over \$150,000

4.) Time span from when you placed your order to when you moved
in _____

FLOOR QUALITY

<u>Floor Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
5.) Squeaks	☐ No squeaky areas	☐
	☐ One or two squeaky areas	☐
	☐ Several squeaky areas	☐
6.) Noticeable Subfloor Joints	☐ No visible subfloor joints	☐
	☐ One or two visible joints	☐
	☐ Several visible joints	☐
7.) Subfloor Rigidity	☐ No "bounce" in floors	☐
	☐ Slight bounce in floors	☐
	☐ Substantial bounce in floors	☐
8.) Carpet Seams	☐ No visible seams	☐
	☐ One or two visible seams	☐
	☐ Several visible seams	☐

9.) Bumps/Bulges in ☐ None ☐
 Carpet or Other ☐ One or two ☐
 Floor Finishes ☐ Several ☐

10.) Carpet Snags/ ☐ None ☐
 Tears ☐ One or two ☐
 ☐ Several ☐

11.) Carpet Stains ☐ None ☐
 ☐ One or two ☐
 ☐ Several ☐

12.) Cuts/Tears in ☐ None ☐
 Sheet Vinyl ☐ One or two ☐
 ☐ Several ☐

13.) Sheet Vinyl ☐ Invisible or none ☐
 Seams ☐ Difficult to detect ☐
 ☐ Very noticeable ☐

14.) Based on the above criteria, how would you rate the overall
quality of the floors in your home?

Poor

Fair

Good

Excellent

Additional Comments? _____

DOOR QUALITY

<u>Door Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
----------------------	--------------------------	-----------------------------

15.) Sticking Doors	() All doors open/close easily	()
---------------------	---------------------------------	-----

() Most doors open/close easily	()
----------------------------------	-----

() Most doors don't open/close easily	()
--	-----

16.) Door Swing	() No doors swing open far enough to hit walls	()
-----------------	---	-----

() One or two doors swing open far enough to hit walls	()
---	-----

() Several doors swing open far enough to hit walls	()
--	-----

- 17.) Door Locks ☐ All work well ☐
 and Hinges ☐ Most work well ☐
 ☐ Most don't work well ☐
- 18.) Drafts Around ☐ None ☐
 Exterior Doors ☐ One or two ☐
 ☐ Several ☐
- 19.) Water Leaks ☐ None ☐
 Around Exterior ☐ One or two ☐
 Doors ☐ Several ☐

20.) Based on the above criteria, how would you rate the overall quality of the doors in your home?

Poor Fair Good Excellent

Additional Comments: _____

INTERIOR WALL QUALITY

<u>Interior Wall Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
21.) Nail Pops (nail head sticking out of wall)	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
22.) Cracks	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
23.) Wallboard Joints	☐ None noticeable	☐
	☐ One or two noticeable	☐
	☐ Several noticeable	☐
24.) Bulges in Walls	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
25.) Evenness of Paint	☐ No shadows	☐
	☐ One or two shadows	☐
	☐ Several shadows	☐

26.) Paint Drips/Runs ☐ None ☐
 ☐ One or two ☐
 ☐ Several ☐

27.) Corners Straight ☐ All straight & even ☐
 and Even ☐ Mostly straight & even ☐
 ☐ Mostly uneven ☐

28.) Wallpaper ☐ No gaps ☐
 (if applicable) ☐ One or two gaps ☐
 ☐ Several gaps ☐

☐ Pattern matches at all seams ☐
☐ Pattern matches at most seams ☐
☐ Pattern doesn't match at most ☐
 seams

29.) Based on the above criteria, how would you rate the overall
quality of the walls of your home?

Poor

Fair

Good

Excellent

Additional Comments: _____

QUALITY OF CEILINGS

<u>Ceiling Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
-------------------------	--------------------------	-----------------------------

30.) Nail Pops (nail	☐ None	☐
heads sticking	☐ One or two	☐
out of ceiling)	☐ Several	☐

31.) Noticeable	☐ None	☐
Joints	☐ One or two	☐
	☐ Several	☐

32.) Sags/Bulges	☐ None	☐
	☐ One or two	☐
	☐ Several	☐

- 33.) Evenness of ☐ No shadows ☐
 Paint ☐ One or two shadows ☐
 ☐ Several shadows ☐
- 34.) Corners Straight ☐ All straight & even ☐
 and Even ☐ Mostly straight & even ☐
 ☐ Mostly crooked & uneven ☐
- 35.) Cracks ☐ None ☐
 ☐ One or two ☐
 ☐ Several ☐

36.) Based on the above criteria, how would you rate the overall quality of your home's ceilings?

Poor

Fair

Good

Excellent

Additional Comments: _____

QUALITY OF WINDOWS

<u>Window Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
37.) Broken Window	☐ None	☐
Panes	☐ One or two	☐
	☐ Several	☐
38.) Leaking Windows	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
39.) Drafts Around	☐ None	☐
Windows	☐ One or two	☐
	☐ Several	☐
40.) Sticking Windows	☐ None	☐
	☐ One or two	☐
	☐ Several	☐
41.) Thermal Effective- ness	☐ No cold air through window glass	☐
	☐ Slight amount of cold air through glass	☐
	☐ A lot of cold air through window glass	☐

42.) Based on the above criteria, how would you rate the overall quality of your home's windows?

Poor

Fair

Good

Excellent

Additional Comments: _____

EXTERIOR WALL QUALITY

Exterior Wall Finish What Did You Get? What Did You Expect?

Criteria

43.) Buckles/Gaps in	☐ None	☐
Siding	☐ One or two	☐
	☐ Several	☐

44.) Leaks Through	☐ None	☐
Walls	☐ One or two	☐
	☐ Several	☐

45.) Based on the above criteria, how would you rate the overall quality of the exterior wall finishes of your home?

Poor

Fair

Good

Excellent

Additional Comments: _____

PLUMBING SYSTEM QUALITY

<u>Plumbing Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
--------------------------	--------------------------	-----------------------------

46.) Water Pressure	() Good Pressure when several faucets & appliances running	()
	() Adequate pressure when several faucets & appliances running	()
	() Inadequate pressure when several faucets & appliances running	()

- | | | |
|------------------------|--|--------------------------|
| 47.) Leaks at Faucets | ☐ None | ☐ |
| and Appliances | ☐ One or two | ☐ |
| | ☐ Several | ☐ |
| | | |
| 48.) Leaks in Plumbing | ☐ None | ☐ |
| System | ☐ One or two | ☐ |
| | ☐ Several | ☐ |
| | | |
| 49.) Hot Water | ☐ Hot water flows | ☐ |
| | immediately when | |
| | faucet is opened | |
| | ☐ Hot water flows a few | ☐ |
| | few seconds after | |
| | faucet is opened | |
| | ☐ Takes a while for hot | ☐ |
| | water to flow after | |
| | faucet is opened | |
| | | |
| 50.) Taste of Plastic | ☐ None | ☐ |
| | ☐ Slight | ☐ |
| | ☐ Significant | ☐ |

Poor	Fair	Good	Excellent

ELECTRICAL SYSTEM QUALITY

52.) Electric Panel Box (☐) Breakers labeled (☐)

 (☐) Breakers not (☐)

 labeled

 (☐) Convenient location (☐)

 (☐) Inconvenient location (☐)

- 53.) Frequency of Circuit Breakers Tripping ☐ Never ☐
☐ Once in a while ☐
☐ Frequently ☐
- 54.) Light Switches ☐ Conveniently located ☐
☐ Inconveniently located ☐
- 55.) Light Fixtures ☐ Sufficient number ☐
☐ Too few ☐
☐ Too many ☐
- 56.) Electrical Efficiency ☐ Low electric bills ☐
☐ High electric bills ☐
- 57.) Wall Receptacles ☐ Convenient location ☐
☐ Inconvenient location ☐

☐ More than enough ☐
☐ Sufficient number ☐
☐ Insufficient number ☐

☐ All receptacles work ☐
☐ Most work ☐
☐ Most don't work ☐

58.) Based on the above criteria, how would you rate the overall quality of your home's electrical system?

Poor Fair Good Excellent

Additional Comments: _____

ROOF QUALITY

<u>Roof Criteria</u>	<u>What Did You Get?</u>	<u>What Did You Expect?</u>
----------------------	--------------------------	-----------------------------

59.) Roof Leaks	☐ None	☐
-----------------	-------------------------------	--------------------------

☐ One or two	☐
-------------------------------------	--------------------------

☐ Several	☐
----------------------------------	--------------------------

60.) Shingle Pattern	☐ Straight & even	☐
----------------------	--	--------------------------

☐ Slightly uneven	☐
--	--------------------------

☐ Mostly uneven	☐
--	--------------------------

- 61.) Shingles Laying Down ☐ All shingles lay down flat ☐
 ☐ One or two shingles not laying down flat ☐
 ☐ Several shingles not laying down flat ☐
- 62.) Shingles Blowing Off in Wind ☐ None ☐
 ☐ One or two ☐
 ☐ Several ☐
- 63.) Roof Bulges/Sags ☐ None ☐
 ☐ One or two ☐
 ☐ Several ☐

64.) Based on the above criteria, how would you rate the overall quality of your home's roof?

Poor

Fair

Good

Excellent

Additional Comments: _____

GENERAL

65.) Is there any aspect of your home that greatly exceeded your expectations or that you are extremely pleased with? _____

66.) Is there any aspect of your home that fell far short of your expectations or that you are extremely disappointed with? _____

67.) How do you feel about the length of time it took to have your home built?

- () much less than expected
- () less than expected
- () about what expected
- () longer than expected
- () much longer than expected

68.) How do you feel about the price you paid for your home?

- ☐ much lower than expected
- ☐ lower than expected
- ☐ about what expected
- ☐ higher than expected
- ☐ much higher than expected

69.) In your own words, how would you define a high quality home? _____

70.) What would your recommendation be to someone interested in purchasing the same home from the same manufacturer?

- ☐ strongly recommend to buy
- ☐ recommend to buy
- ☐ indifferent
- ☐ recommend not to buy
- ☐ strongly recommend not to buy

Reason: _____

APPENDIX E
BUILDER SURVEY RESULTS

BUILDER SURVEY RESULTS

MFCTR A+MFCTR B+MFCTR C

QUALITY OF MFCTR SERVICE	Didn't Meet	Met	Exceeded
delivery	0	19	0
service calls	2	11	6
design errors	5	7	7
special dsgn requests	0	9	10
Totals	7	46	23
Percentages:	9%	61%	30%

Overall Rating

excellent	8
good	10
fair	1
poor	0

GENERAL QUALITY OF MODULES	Didn't Meet	Met	Exceeded
squareness of walls	8	11	0
module dimensions	4	14	1
fit on foundation	5	14	0
fit w/ other modules	6	12	1
ship loose materials	7	11	1
Totals	30	62	3
Percentages:	31%	66%	3%

Overall Rating

excellent	7
good	8
fair	4
poor	0

QUALITY OF FLOORS	Didn't Meet	Met	Exceeded
squeaks	4	14	1
noticeable joints	4	13	2
rigidity	2	14	2
visible carpet seams	5	12	1
bumps/bulges	2	14	1
carpet snags/tears	3	13	1
carpet stains	1	14	1
sheet vinyl cuts/tears	4	12	1
sheet vinyl seams	3	13	1
Totals	28	119	11
Percentages:	18%	75%	7%

Overall Rating

excellent	8
good	9
fair	2
poor	0

QUALITY OF INTER. WALLS	Didn't Meet	Met	Exceeded
cracks	5	12	2
nail pops	9	9	1
visible joints	5	11	3
bulges	6	12	1
evenness of paint	6	11	2
paint drips/runs	6	12	0
matching touchup paint	4	15	0
corners straight & even	8	11	0
wallpaper	1	14	1
Totals	50	105	10
Percentages:	30%	64%	6%

Overall Rating	
excellent	10
good	3
fair	4
poor	2

QUALITY OF CEILINGS	Didn't Meet	Met	Exceeded
cracks	3	16	0
nail pops	3	15	1
visible joints	6	11	2
evenness of paint	6	12	1
corners straight & even	5	13	1
sags/bulges	5	13	1
Totals	28	80	6
Percentages:	25%	70%	5%

Overall Rating	
excellent	9
good	7
fair	3
poor	0

QUALITY OF EXTR. WALLS	Didn't Meet	Met	Exceeded
matching siding pattern	3	13	1
buckles/gaps in siding	6	9	2
leaks through walls	3	16	0
Totals	12	38	3
Percentages:	22%	72%	6%

Overall Rating

excellent	8
good	8
fair	3
poor	0

ROOF QUALITY

Didn't Meet	Met	Exceeded
-------------	-----	----------

matching shingle pattern	0	19	0
torn/broken shingles	6	11	2
shingle tabs sealed	5	12	1
shingle pattern straight	3	15	1
shingles lay down flat	3	15	1
roof bulges/sags	7	11	1
roof leaks	4	14	1
tilt-up roofs	7	12	0

Totals	35	109	7
Percentages:	23%	72%	5%

Overall Rating

excellent	7
good	11
fair	1
poor	0

QUALITY OF WINDOWS

Didn't Meet	Met	Exceeded
-------------	-----	----------

broken panes	1	16	2
leaking windows	2	15	2
sticking windows	3	14	2
properly flashed	4	13	2

Totals	10	58	8
Percentages:	13%	76%	11%

Overall Rating

excellent	12
good	6
fair	1
poor	0

QUALITY OF DOORS

Didn't Meet	Met	Exceeded
-------------	-----	----------

sticking doors	5	12	1
defective hardware	5	11	2
drafts around ext doors	8	8	2
water leaks-extr doors	7	10	2

Totals	25	41	7
Percentages:	34%	56%	10%

Overall Rating

excellent	8
good	4
fair	4
poor	1

QUALITY OF PLUMBING SYSTEMS	Didn't Meet	Met	Exceeded
code violations	3	15	0
discrepancies from plans	3	14	1
leaks at fixtures	6	12	0
leaks within system	8	8	2
broken pipes/fittings	7	10	1
Totals	27	49	4
Percentages:	30%	66%	4%

Overall Rating	
excellent	6
good	9
fair	2
poor	2

QUALITY OF ELECTRICAL SYSTEMS	Didn't Meet	Met	Exceeded
code violations	4	14	0
discrepancies from plans	7	10	1
faulty lights/switches	5	13	0
faulty receptacles	7	11	0
faulty breakers	4	14	0
Totals	27	62	1
Percentages:	30%	69%	1%

Overall Rating	
excellent	7
good	8
fair	1
poor	0

totals:	25%	68%	7%
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APPENDIX F
CONSUMER SURVEY RESULTS

CONSUMER SURVEY RESULTS

MFCTR A + MFCTR C

FLOORS	Didn't Meet	Met	Exceeded
squeaks	6	15	5
joints	7	20	0
rigidity	2	21	3
carpet seams	13	12	1
bumps/bulges	11	12	3
carpet snags/tears	5	20	1
carpet stains	5	21	0
cuts/tears sht vinyl	8	17	0
sheet vinyl seams	2	22	1
Totals	59	160	14
Percentages:	25%	69%	6%

Overall Rating

EXC	9
GOOD	12
FAIR	4
POOR	1

INTERIOR WALLS	Didn't Meet	Met	Exceeded
nail pops	8	15	3
cracks	8	15	3
wallboard joints	4	21	1
bulges	4	21	1
even paint	5	15	2
paint drips/runs	5	18	2
corners	6	17	3
wallpaper	5	22	3
Totals	45	144	18
Percentages:	22%	70%	8%

Overall Rating

EXC	8
GOOD	15
FAIR	3
POOR	0

CEILINGS	Didn't Meet	Met	Exceeded
nail pops	4	21	1
noticeable joints	3	21	2
sags/bulges	2	22	1
even paint	4	17	2
corners	5	19	2
cracks	6	17	3

Totals	24	117	11
Percentages:	16%	77%	7%

Overall Rating

EXC	12
GOOD	10
FAIR	4
POOR	0

EXTERIOR WALLS

Didn't Meet	Met	Exceeded
-------------	-----	----------

buckles/gaps	5	19	2
leaks	2	23	1

Totals	7	42	3
Percentages:	13%	81%	6%

Overall Rating

EXC	16
GOOD	5
FAIR	4
POOR	1

ROOFS

Didn't Meet	Met	Exceeded
-------------	-----	----------

leaks	3	23	0
shingle pattern	1	23	1
laying down	7	18	0
blowing off	3	21	1
bulges/sags	0	26	0

Totals	14	111	2
Percentages:	11%	87%	2%

Overall Rating

EXC	15
GOOD	8
FAIR	2
POOR	0

WINDOWS

Didn't Meet	Met	Exceeded
-------------	-----	----------

broken	1	25	0
leaks	1	25	0
drafts	4	21	1
sticking	1	24	1
thermal effectiveness	3	22	1

Totals	10	117	3
Percentages:	8%	90%	2%

Overall Rating

EXC	20
GOOD	3
FAIR	3
POOR	0

DOORS	Didn't Meet	Met	Exceeded
sticking	8	18	0
free swing	9	16	1
locks & hinges	4	22	0
drafts	7	19	0
leaks	5	20	1
Totals	33	95	2
Percentages:	25%	73%	2%

Overall Rating	
EXC	8
GOOD	15
FAIR	3
POOR	0

PLUMBING	Didn't Meet	Met	Exceeded
pressure	8	16	1
leaks @ fixtures	5	21	0
leaks w/in system	6	20	0
hot water flow	4	21	0
plastic taste	2	24	0
Totals	25	106	1
Percentages:	19%	80%	1%

Overall Rating	
EXC	11
GOOD	10
FAIR	4
POOR	1

ELECTRICAL	Didn't Meet	Met	Exceeded
panel box	4	40	2
tripping breakers	2	22	2
light switches	2	24	0
light fixtures	0	25	0
efficiency	4	18	3
wall receptacles	4	63	6
Totals	16	192	13
Percentages:	7%	87%	6%

Overall Rating	
EXC	17

GOOD
FAIR
POOR

6
2
0

totals: 17% 78% 5%

SPEED OF COMPLETION

Didn't Meet	Met	Exceeded
3	17	6

PRICE

Didn't Meet	Met	Exceeded
2	18	6

RECOMMENDATION TO BUY

TOTAL

strongly recommend yes
recommend yes
indifferent
recommend no
strongly recommend no

15
8
3
0
0