

Quality Engineering- Improving Soap Packaging at Colgate-Palmolive

Erin Boehmer
elboe2@yahoo.com

Max Chang
watermaximillion@gmail.com

Margaret R. Clinton
margzilla@optonline.net

Claire Y. Oh
ohhome@att.net

1 Abstract

In this study, we examine the Softsoap[†] hand soap production line at Colgate-Palmolive, one of the world's most successful and influential brands. We toured the Colgate-Palmolive facility in Morristown, NJ, observing the individual steps taken to create both the Softsoap[†] packaging and actual product. Because of the fast pace of the machinery and both mechanical and human error, some defects were evident, such as bottles missing inserts and bugs in the soap product. We conducted several studies and statistical analyses to better understand the process and the implications of the defects to the company. We found both that Colgate is proficient in many areas of production and yet, that seemingly small defects cost Colgate-Palmolive a significant amount of money every day. We recommend improvements that could be made to the process to yield a higher quality process and product, such as changing the shape of the insert and donating defective, but usable hand soap to local food banks. We also suggest future actions that could be taken at the facility to further improve the process, product, and package.

2 Introduction

Quality engineering is a branch of industrial engineering that involves improving manufacturing processes and doing all that is necessary to meet and exceed customer expectations while saving time and money. To improve the quality of the product, engineers may also focus on improving working conditions within the factory and creating a friendly environment for employees. This branch of engineering is relatively new, as many quality tools and methodologies were devised during the post-WWII era and later by quality experts such as, William Edward Deming and Joseph Juran. Frederick Taylor also played a leading role in improving industrial practices when he wrote The Principles of Scientific Management in 1911 and coined the term “Taylorism”. Taylorism revolutionized the workplace as jobs were made into “sciences.” Each job was accompanied by rules, motion, standardized work implements, and proper working conditions. Managers carefully selected workers with the right abilities for the job and trained the workers, giving them proper incentives to cooperate with the new scientific industry. Bosses also supported employees by planning their work and smoothing out the processes.

There are two principle philosophies in quality engineering: the western philosophy and the Japanese philosophy. The western philosophy focuses on innovation while the Japanese philosophy revolves around the idea that small, frequent, and gradual improvements result in more successful quality improvements in the long term. Strategies such as the Deming Cycle, which is based on the plan, do, study, act cycle, however, play crucial roles in both philosophies and aid quality engineers by generating a structured path from cause to remedy.

In this study, we examined the manufacturing process for creating Softsoap[†] hand soap at the Colgate-Palmolive plant in Morristown, New Jersey. This company is an international manufacturer of oral care, home care, personal care, and pet nutrition products [1]. The hand soap begins as several individual raw materials and a fragrance which is then mixed, packaged, and shipped to consumers worldwide. To help to complete this task, the Morristown plant employs hundreds of workers and operates many different complex machines at rapid paces. As a result, even the smallest mechanical and human errors result in lost time, decreased output, and wasted funds. Therefore, we focused on improving the defects present in the process that were the cause of a majority of the problems within the factory.

Specifically, our group concentrated on the creation of the Softsoap[†] Aquarium Series[†] handsoap. This is a type of liquid hand soap created at Colgate-Palmolive; the soap includes a unique insert that is placed into the bottle by a machine. Inserts feature digitally printed images of fish that can

be seen through clear, colorless liquid soap.

Several of the most important defects that we concentrate on include:

- the crushed appearance of some of the defective bottles
- the inability of the insert machine to place the inserts inside of the bottles with 100% accuracy
- the production of unfilled boxes of hand soap

After observing the manufacturing process for the Softsoap[†], we found that Colgate-Palmolive could greatly improve the quality of their product and manufacturing process by staggering the start of each machine to increase the size of queues, keeping track of the pre-forms, and keeping the processing lines more sterile.

3 Background

Many companies use the six sigma system to maintain high quality standards within their company. Six sigma is a business management strategy based on the statistical standard in which units conform to specified ranges even six sigmas from the mean in both directions. This means that over 99% of the units will fall within that specified range.

3.1 Quality Tools

In order to study processes, quality engineers utilize many different statistical tools that provide a variety of insights into the possible causes of defects. There are seven key quality tools that quality specialists frequently employ. In this study, we used several of the pertinent methods to aid us in our examination of the manufacturing of Softsoap[†] handsoap.

Flowcharts: Flowcharts present a symbolic representation of the process; each step corresponds to a shape, such as a circle or a square, depending on the actions that take place during the step. For example, if one step includes moving raw materials from the first floor of the establishment to the second floor, then this step would be represented as an arrow, which signifies transportation. Flowcharts aid individuals in objectively studying and understanding each step of a process, and thus the process as a whole. Employees and managers are then able to distinguish between ideal circumstances and reality. This tool reveals unpredicted complexity, problem areas, redundancy, unnecessary loops, and possible areas for simplification, and thus makes it easier for engineers and company representatives to decide which potential remedies would be most effective.

Check Sheets: This graphical representation of data is easy to create and the results can be interpreted directly on the form, requiring no additional processing. With each observation of the process, the true picture of the process becomes clearer and patterns in the data become evident, quickly forcing those working on the project to agree on which problems require the most attention.

Histograms: Histograms provide quality engineers with information about the parent population from which the samples are taken. A large amount of information can be observed on histograms. Because of the orientation of a histogram, the distribution and patterns in the data, such as centering and variation, become obvious.

Pareto Diagrams: These graphs are similar to histogram, except the data is arranged from largest frequency to

smallest. This helps individuals to concentrate on those problems that are causing the most defects. Pareto diagrams also prevent people from shifting the problem from one to another.

Cause and Effect Diagrams: The cause and effect diagram, or fishbone diagram, is a simple tool that helps quality experts think about possible causes of a problem and how the problems and causes could be interrelated (See Appendix C).

Poka-Yoke: This is an approach for mistake-proofing processes using automatic devices to avoid simple human error, such as forgetfulness, misunderstanding, or lack of experience.

3.2 Package Manufacturing

Manufacturing companies have the choice of a variety of methods to create packages. One option is blow molding; in this method, a machine blows high temperature, high pressure air into a pre-form (see Figure 1) located inside of a metal mold. The pre-form takes the shape of the mold and is ejected from the machine and cooled with water. Colgate-Palmolive uses this technique to manufacture The Softsoap[®] bottles.



Figure 1 - Pre-forms are test tube like dense polymer parts with a threaded neck finish and are produced on an injection mold machine.

Another important technique used in manufacturing Softsoap[†] hand soap containers is injection molding. This process involves a resin hopper that feeds into a heated compartment. The resin is heated and injected into a channel and then into a mold. The molded part may then be cooled and ejected from the machine. This process allows for the creation of multiple component parts, as individual resins can be injected into the mold at different cycle periods. This method is used to create the pump tops of the hand soap bottles, although they are not manufactured in the Colgate-Palmolive plant.

Lamination is also employed within the Morristown facility to create labels for the soap bottles. During this process, a plastic film is created and processed. Multiple layers of the film are pasted together, or laminated, creating a composite film product.

4 Related Work

Previous studies show that packaging is of vital importance. “It is no longer sufficient that the product be of good quality and represent good value. Today packaging and the design play a major role in its success or failure” [2]. Since packaging is so important, it is not surprising that 83.6% of labor on cosmetic products is work on the packaging, not the product itself [2].

Modern packaging design has three major goals, protection of the product, aesthetic appeal, and cost effectiveness [2]. Packaging, especially soap packaging, should, “provide adequate protection for the normal life of the product, plus a reasonable margin of safety” [2]. Along with the long shelf

life, the packaging should also “...attract the customer, identify the product and brand name, tell its story, and close the sale” [2]. On top of being pragmatic and appealing to the eye, the bottles must be cost effective. They should accomplish the packaging needs at the least possible cost. For example, universally, companies produce bottles that look as large and filled as possible, but do not actually hold more product, so that they may increase sales and decrease cost.

5 Engineering Design

To gain some knowledge on the soap process we were trying to improve, our first stop was the Colgate plant in Morristown, New Jersey. Our goal was to gain an understanding of the manufacturing process of Colgate’s liquid hand soap and to have an overview of the factory. As we went on the tour through the factory, we were able to observe the entire assembly line for our target product- the Softsoap[†] Aquarium Series[†] Antibacterial Soap- from the raw materials Colgate received to the finished product. We observed how the pre-forms were blown up and how the inserts were placed into the bottles. We were also able to study how the soap was created from its ingredients, how the soap was placed into the bottles, and how the bottles were packaged for shipment. We carefully scrutinized the process and asked the operator numerous questions. We took tallies of defects that we noticed in the plant as well.

We applied the quality control tools to Colgate’s process. Using our newly acquired information, we created flowcharts, cause-and-effect diagrams, and check sheets (See Appendix C). First, to condense the multi-hour tour

into simplistic steps, we created a flowchart so we could have an overview of the manufacturing process of Colgate's liquid hand soap. The Colgate manufacturing plant was split into two floors: the pre-make floor and the finishing line. The main goal of the pre-make floor was to prepare all the mixtures for the final assembly downstairs. All ingredients that Colgate imported from the outside were tested. If the ingredients passed the test, a pink slip was posted on the sac or bin. This allowed the employees to differentiate between the ingredients that were safe to use and those that had not been checked yet. This floor also had separate batches of vanilla, the colorless liquid soap base, and fragrance. Downstairs, skids mixed the final soaps from the fragrances and vanillas. The bottles were blown molded and soap was injected into them. Then the soaps were packaged and stored in the storage room.

Another tool we utilized was the check sheet. The check sheet listed the defects we observed and predicted could occur in the process. We included defects like:

- Labels have incorrect orientation
- Inserts do not stay in the bottles
- Soap bottles are overfilled
- An unstable bottle due to too much pressure on the bottle walls

Later, in our second trip to Colgate, we were able to receive a check sheet of the defects that Colgate employees checked. We also created cause-and-effect diagrams for problems like unfilled boxes, large bottles with a crushed appearance, and inserts not being orientated correctly. In the diagrams, we

brainstormed possible causes behind these defects.

We began our experiment by measuring the dimensions of the bottles. We measured the height and width of the bottle; the width of the neck of the bottle; and the height of the pumps. Then we examined and counted the number of black spots on each bottle. The black spots occurred because the materials were re-melted too many times. We also examined the inserts, since they were a major problem we observed during our tour. Often, many inserts did not enter the bottle correctly, causing the process to be slowed or possibly stopped, so that the inserts could be put in manually. We tried to manually insert some of the inserts to see how difficult the insert was to place inside the bottle.

After measuring the dimensions for the bottles, we tested the strength of water-filled bottles using the compressor machine. The machine compressed each of the bottles between two metal plates, applying steady pressure until the bottles yielded. The machine was attached to a computer, which kept track of how much pressure was being applied to the bottle and the rate at which the bottle yielded (See Appendix A). We used water to replicate the soap-filled bottles. Even though water has a lower viscosity than soap, it was better to have some sort of liquid substance in the bottle. We used this data for the analysis in section 6.2.

6 Results

6.1 Bottle Dimensions

We found, as shown in Figure 2, that the standard deviation for the dimensions of the sample of 7 bottles, was relatively small. This means that the dimensions of these bottles were consistent. Also shown in figure 2, the

standard deviation of pumps' heights was larger, meaning that the pumps' heights were less consistent than the bottles' dimensions. The pumps, unlike the bottles, are not produced at Colgate, and the pumps allow for a broader range of acceptable heights. The straws of the pumps are manufactured shorter than the bottles that house them, so that very few pumps ever reach the bottom of the bottle. If a pump were to reach the bottom of the bottle it would cause suction, which would make pumping the soap difficult.

Dimension	Mean	Standard Deviation
Height of bottle	5.0389"	.0045"
Width of bottle	3.3459"	.0068"
Width of mouth of bottle	.8640"	.0012"
Height of pump	5.3515"	.0255"

Figure 2- Chart of mean and standard deviations of bottle dimensions.

6.2 Bottle Strength

By testing a sample of bottles filled with water in a compressor machine we found that the bottles would not buckle unless under around 112.32 pound forces which is around 25 Newtons. This amount of force would never reasonably be exerted onto a soap bottle; it is equivalent to placing a 6 pound bowling ball on top of a soft soap container. After the pressure was decreased on the tested bottles, they would return to their original state, with only a few creases or wrinkles.

6.3 Production Efficiency

We have approximated, through analysis of Colgate's goals of 75,000 cases per day, and of the line running 63% of each shift, that their goal day would entail producing about 83 cases

per minute. On the days we toured the plant, an average of 76,071 cases were produced per day, and the plant ran, on average, 57.82% of the day. These figures led us to approximate that the plant was producing at a rate of 91 cases per minute. Although the plant was running during less of the day than the goal day, it still exceeded the expectations for daily production.

6.4 Inserts

Given that 2% of inserts are not correctly placed by the machines, and that 91 cases are produced per minute, we approximate that 10-21 bottles per minute will have incorrectly placed inserts. With two workers at each station, every 6-12 seconds a worker will have to fix the placement of the insert. However, nonconforming bottles often occurred in streaks of two or three. At this rate, around 8,000 bottles each day will have incorrectly placed inserts. When inserts are incorrectly placed, about half of the time they fall out of the bottle and are unusable. This cost adds up to around \$116 each day in wasted inserts.

6.5 Recycling

Since PETE resin can only be processed two times before the resin loses strength, the percentage of bottles recycled becomes an important consideration. Colgate recycles around 10% of bottles rejected after the blow molding phase. If 97.5% of bottles are molded correctly, we calculate an approximate breakdown of all of the pre-forms processed in one day as shown in Figure 3. This chart shows that 21,132 pre-forms go to waste. The cost of this many pre-forms going to waste adds up to an approximate cost of nearly \$998.28

per day, but there are only around six pre-forms being processed a third time.

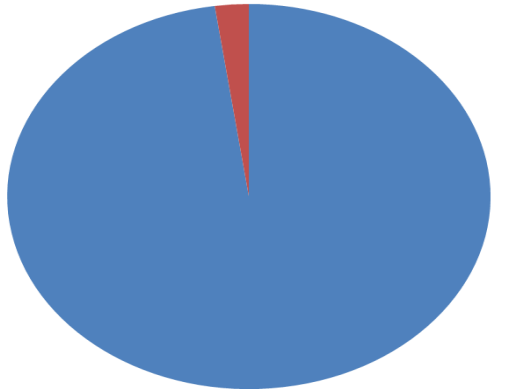


Figure 3- Pie chart breaking down results of bottles processed in 1 day.

- Blue - Successful bottles (915132 pre-forms)
- Red - Wasted bottles (21132 pre-forms)
- Green - Over processed bottles (6 pre-forms)

questions at the Colgate-Palmolive factory, along with our own studies and experimentation, we have come to conclusions on what the major defects in the Softsoap[†] manufacturing process are. These defects have two impacts on the efficiency of Colgate's production. First, some of the defects cause damage to materials making them unusable. Second, the other defects cause delays that waste time. Both of these results cost the company money and harm productivity.

7.1 Major Defects and Recommendations

7.1.1 Bottles

The process that blows out the pre-forms into the bottle shape causes defects. While we were brought around the factory, it was evident that many bottles were taken off the conveyor belt because of deformities such as indentations or incorrect size. About 10% of these bottles are melted down

into pre-forms and reused, however the other 90% are just recycled. If only 10% of each load is reused, then many bottles are being disposed of before they are reused twice. This results in wasted supplies.

We recommend that Colgate keep track of the number of times each bottle has been blown in order to be more cost effective and efficient. This would allow all bottles to be used twice before they are disposed of. This would save \$998.28 per day and reduce the amount of waste that the plant produces.

7.1.2 Inserts

The machine that places inserts into the hand soaps is a major source of defects. Many of the bottles passing through this process either have an insert that is put in incorrectly or have no insert at all because the machine dropped the insert before it reached the mouth of the bottle. In addition, sometimes, there are slots in the machine where a bottle is missing, yet the machine still tries to put in an insert. This results in the insert being dropped and wasted, thus costing Colgate supplies and money.

Although we have no access to the insert machine itself, we believe that a possible source of error for the insert machine is the shape of the insert. The inserts are too blunt at the bottom corner. If it is sharper, then it would be easier for it to be placed into the bottles. (See Appendix B.1 and B.2) This would reduce the number of defects, thus saving the company money. In addition, the revised inserts would require less plastic, thus costing the company less money.

7.1.3 Empty Slots

At many points, machines were in operation but there were no bottles in queue thus decreasing productivity. In

addition, if the machine is not accomplishing anything it is also wasting electricity. The productivity of the plant can be improved if the time that a machine is running is used effectively.

Many machines continued to operate even though there were no bottles going through. This can be solved if the machines are started up at different times. The equipment should be turned on in sequential order. Insofar, as a larger queue is created before each machine, the amount of time machines are being unproductive would be reduced, thus saving the company additional money.

7.1.4 Foreign Matter

Lastly, Colgate informed us of their most common consumer complaints. Among the top three was that foreign matter was found in the product. Foreign matter ranges anywhere from pieces of metal to hair to insects. At the plant, many, if not all of the machines are surrounded by plastic shields that prevent dust and other foreign particles from entering the machinery. There are other ways that the foreign matter could have gotten into the soap. Many of the bins that held the individual pieces were exposed. If particles fell into these bins, they could become attached to one of the pieces and end up in the finished product.

Foreign matter is harmful to customer satisfaction. In order to reduce the frequency of this defect, Colgate ought to increase the sterility of the production lines. Obviously, some parts of the line must be easily accessible in order to pull off samples and make quick repairs. However, the remaining parts of the line should be covered. To start, the bins that hold the individual parts should be covered at all times. We recommend

that Colgate simply place signs on the underside of each of the bins' lids that remind the workers to keep the covers closed. In addition, the employees along the production lines should wear hair nets while working.

7.2 Positive Conclusions

Along with the defects, our studies revealed good process and product design elements. After repeated testing, almost all of the bottles returned to their original shape with nothing but a few creases. Secondly, our measurements show a minimal variation in the bottles. Lastly, Colgate's plant is designed and run well. The space in the factory is well utilized and the employees' safety is held in the highest regard.

7.3 Help the Community

While we were at the plant, we noticed that many bottles, already filled with soap, were thrown away because of slightly defected labels. These bottles could be donated to a homeless shelter or similar organization that helps the less fortunate. The benefits of this action are twofold. First, the soap could be utilized instead of just being thrown away. Second, Colgate could obtain a tax break which would save them more money each year.

8 Future Work

Using our results, Colgate can do some further experimentation to advance its manufacturing process. Colgate could study the pressure distributions of this Aquarium Series[†] Antibacterial Soap closely with specialized technology. They could get an accurate approximation of the thickness of the bottle. Colgate could also study the

pressure distribution of all the bottles and fix the weak spots of the bottles.

We also think that Colgate should, if they have not already, invest time into studying the available polymers, to evaluate their potential as bottles. For example, they could study which plastic is the strongest and which plastic can be used as a good fragrance barrier. They could invest time to create a more eco-friendly soap bottle that uses less plastic.

Colgate should study the vacuum and suction cup system used to pick up the inserts and place them into the bottles. The material would probably be less slippery and less flimsy than the present one. Inserts of a different shape or material could be better suited to the system. or the system itself could be improved to reduce defects.

9 Conclusions

This project delved into many important aspects of quality engineering. We performed all the basic steps that quality and industrial engineers pre-form, starting from visiting the Colgate plant and observing the packaging line all the way to presenting our findings and recommendations. The goal of quality engineering is to take a product or process and make it better in a cost effective way.

In the analysis of our observations and findings we were exposed to many quality tools. We used our data to create charts and graphs, which we used to draw conclusions. In addition, we gained experience working with industrial tools like the compressor and calipers.

During our two trips to Colgate, we learned the ins and outs of the soap making and packaging process. We

experienced the process from start to finish. In our discussion with industrial engineers at Colgate, we learned that Colgate does an excellent job of maintaining quality control at a level where profits are not severely affected.

After analyzing all of our observations and calculations we came up with a few sources of defects and recommendations. The process that makes the bottles out of pre-forms was not completely efficient, making many deformed bottles. Although this flaw is inevitable, we suggest that Colgate keep track of their pre-forms so that they can be melted down and reblown as many times as possible.

The insert machine was also a problem; it regularly failed in placing the insert into the bottle. This problem could be solved by changing the shape of the insert so that it has a sharper bottom, thus making it easier to insert into the mouth of the bottle.

We noticed that machines were running inefficiently, that is to say many machines ran even though no bottles were being processed. In order to solve this problem, the machines should be started in sequential order. This would allow a longer queue to build up so the machine is more efficient while it is running.

Foreign matter in the bottles was one of the top consumer complaints. If the environment around the bottles was kept more sterile, the frequency of this defect could be reduced. This can be accomplished by closing bins and wearing both hair nets and gloves. Lastly, bottles that are going to be thrown away because of labeling defects, should be donated to homeless shelters in order to help the community and obtain a tax break for Colgate.

Also, consideration should be taken to see if a change in the shape of the pump or in the bottle would allow for the pump to reach to bottom of the bottle. If this were so, then all the soap could be easily dispensed.

10 Acknowledgments

We would like to extend our gratitude to the following people for giving us the opportunity to work on this research project:

Our advisor, Mike Brown, for teaching us all of the background information necessary to do this project, traveling with us to the Colgate-Palmolive factory, dealing with our shenanigans, and guiding our work with constructive criticism.

Our RTA mentor, Caleb, for bring us back and forth from class, accompanying us to Colgate, taking us to McDonald's, being a dinosaur, and providing guidance on our project.

Patrick Jones, for being our liaison between Colgate and Governor's School and providing us with an insider's look at the Colgate plant.

Bill Cook, the Quality Control Director, for answering our questions, solving one of life's great mysteries, and graciously allowing us to tour and analyze the Softsoap[†] line.

Karol and Alex, quality engineers at Colgate, for showing us the ins and outs of Colgate and teaching us what its like to be a quality engineer in the corporate world.

Sean DiStefano, for editing our paper and presentation.

Ms. Jane Oates and the Governor's School Board of Overseers for providing us the opportunity to participate in this wonderful experience.

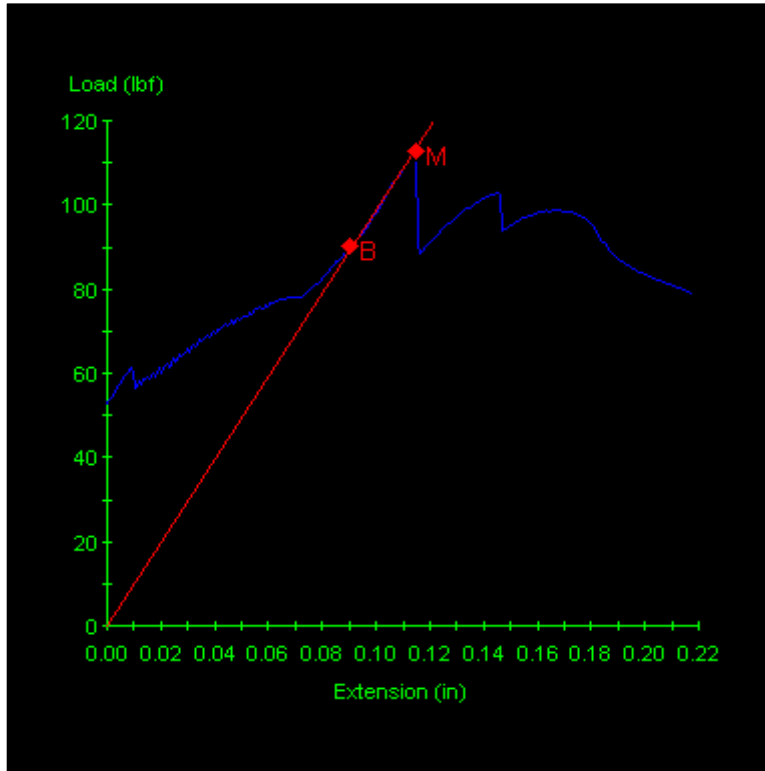
Rutgers, the State University of New Jersey, New Brunswick, for being a wonderful host.

Dean Don Brown and Dean Ilene Rosen, for the opportunity to attend Governor's School of Engineering and Technology. Blase E. Ur, for providing us with all of the resources needed in order to make our project a success, having a great name, and running a fantastic summer program.

11 References

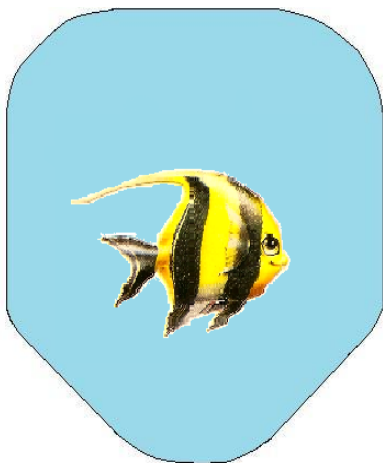
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Appendix A: Tensile Strength Graph



Appendix B:

B.1: Original Insert Shape



B.2: Revised Insert Shape



Appendix C: Cause and Effect Diagrams

