Chris A. Ortiz

Kaizen Assembly

Designing, Constructing, and Managing a Lean Assembly Line

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About the Author

Chris Ortiz is a senior lean consultant and the owner of Kaizen Assembly, a lean manufacturing training company in North Carolina. Before starting Kaizen Assembly, he worked for a number of Fortune 500 companies, holding titles such as senior lean engineer, lean coordinator, kaizen coordinator, and corporate lean advisor.

Chris has been featured in a variety of engineering magazines and trade newsletters such as *Industrial Engineer*, *Industrial Management*, and *Manufacturing Engineer*'s lean newsletter. He is a member of the Institute of Industrial Engineers and the Society of Manufacturing Engineers.

Chris is an active speaker on lean manufacturing and kaizen and conducts workshops and seminars all over the country. Today, he and his family reside in Winston Salem, NC. He can be reached at www.kaizenassembly.com.

Introduction

It is 9:30 a.m. and it is business as usual at the Company Z manufacturing plant. Product is being pushed down the assembly line at a rapid rate. The production supervisors are pacing back and forth, overseeing the interactions between people and product like field marshals analyzing their troops before battle. The constant sense of urgency forces operators to ignore standard operating procedures and critical quality responsibilities. Product begins to pile up between workstations, and operators are witnessed hunting for parts and tools.

Work instructions are scattered across the production floor, collecting dust. Tools malfunction and parts do not arrive at the workstation when needed. New employees stand around looking confused, not knowing what to do or what to ask. Operators leave their workstations to talk on cell phones and to interact with fellow employees working on other assembly lines.

The workstations are poorly constructed and do not adhere to any ergonomic or safety criteria. Work content is severely imbalanced, forcing operators to stand around looking for something to do rather than working. Parts and material presented to each workstation are so poorly organized that operators spend a majority of their time wandering and searching, their faces masked with confusion. Crisis management and volume are the primary focus, so issues are resolved as they arise, rather than finding long-term solutions. Every hour that passes is one step closer to the end of the day, which will bring some form of relief. At last, it ends with the typical, middle management production meeting that involves a semiheated exchange of problems and quick fixes. Sound like your company? You are not alone.

Recognizing the problems that exist on your production floor is the first step to success. Many manufacturers are fully aware of the issues and challenges that create roadblocks to success, yet do nothing about it. Rather than attempting to resolve these issues, two things typically occur. First of all, problems are addressed "on the fly." Quick fixes, or bandaids, are applied, allowing production to continue on in the short term while realizing that the problem will resurface again, possibly in the same day. Also, these quick fixes can often create even larger problems in the future. This inefficient approach to problem solving creates a reactive thinking culture, one that will never search for long-term solutions. This self-destructive mind-set sets the tone for acceptance of problems and issues as a familiar part of the process, while remaining focused on driving product through unresolved situations, as the normal business practice. In simpler terms, it breeds a common thought among all, as well as the familiar statement, "It has always been this way."

One of the companies that I used to work for maintained a similar culture. Efforts towards resolution were disorganized and involved too many people, with no certain plan or direction. Small, separate groups were created to focus on multiple problems and areas at the same time. The groups consisted of a continuous improvement team, a process engineering team, a quality engineering team, a 5S team, and a lean engineering team. Every group was assigned different tasks that the company deemed important. Each team would meet on separate occasions, usually once a week, to discuss the projects and possible solutions, not knowing what the other groups were addressing. They had to juggle their usual day-to-day responsibilities with the assignments of their team. There was no clear vision or future goal, and the teams worked for months, never resolving anything. This resulted in inconsistent participation, tension, low morale, and — worst of all — no outcome.

Finally realizing that these highly qualified employees could not tackle and fix the problems in their assembly lines, the company acquired help from external consulting firms and purchased dozens of books on lean manufacturing, 5S, assembly line design, and various training manuals. Nothing helped. Again, does this resemble your company?

Currently, there are hundreds of consulting firms available to help your company become a smoother, more efficient-running operation. And for every consultant, there is an endless supply of books about how to design manufacturing processes that will help reduce waste, improve productivity, enhance quality, and, more importantly, keep assembly lines from going overseas. I have read plenty of these books and they have helped me develop a better understanding of the concepts mentioned above; however, I must point out that most of them are about creating a lean business as a whole. And although valuable, they did not explain in full detail how to implement this type of change on the production floor.

Although there is plenty of good data available, many manufacturing companies cannot obtain world-class level on the shop floor because much of the information is hard to understand. Managers often struggle between knowing what it takes to design the process, and also what it takes to keep the process running smoothly after implementation. The majority of manufacturing consulting firms that teach Six Sigma, lean manufacturing, 5S, and other highly effective practices can guide companies in the direction that is needed, although lean management seems to be a less experienced area. Another important fact to note is that in most cases, these consultants do not remain on site to teach and change the culture operating the new processes, which would ultimately ensure the success of the new implementation. As a lean manufacturing consultant, I realize that this type of service is difficult, due to the sheer number of clients maintained by the average consulting firm. This is what inspired my creation of this book, as a tool to assist our customers.

Kaizen Assembly removes the confusion, and provides a step-by-step guide, with the objective of helping companies get assembly lines operating at optimum potential. This book will bring kaizen and lean management

together, demonstrating how kaizen can be used to effectively deliver the lean philosophies to the plant floor, with clear, succinct, and understandable language, rather than the use of such ambiguous terms as stamping, pressing, and welding, which rarely apply to many production environments.

This book will begin by explaining the importance of upper management's commitment to change, and why that is critical in implementing a company kaizen program, as well as driving and sustaining improvements in the company. By utilizing the skills of your own people, *Kaizen Assembly* will then guide you along the appropriately individualized path to success, designing an assembly line for an electric motor powered bike as a solid teaching example. The process of setting up a lean assembly line is better illustrated by the use of a real product. I chose an electric bike because it has a variety of different parts that are installed using common processes found in many manufacturing environments. The installation of painted parts, welded parts, a wire harness, wire ties, lights, tires, a battery, and so forth requires various air tools and hand tools, and the bike itself requires testing, inspection, and packaging. All of the necessary processes are familiar to a basic assembly line. The bike will be built on a ten-station main assembly line, a three-station subassembly feeder, and a subassembly work cell.

The electric bike assembly line in this book will be designed and constructed on site during a one-week kaizen event. The changes will encompass the concepts of waste reduction, 5S, standard work, and visual management. *Kaizen Assembly* will break down the key elements in establishing the kaizen governing committee, the kaizen champion, kaizen teams, schedules, time and motion studies, line balancing, culture change, waste reduction, training, station design, and construction.

Each kaizen day will be described in detail: how to conduct kaizen meetings, report out sessions, and set daily goals. By using the electric bike as our product, every aspect of setting up the assembly line is defined and can be clearly understood.

Although each lean implementation should be tailored to fit the needs of its company, the kaizen system has been proven to work for any size company regardless of the product manufactured. Washing machines, computers, bicycles, generators, air conditioners, furniture, air tools, lawn mowers, or any other type of product, all have one major similarity: the parts must be fabricated and brought together to make the end product. That is the reason kaizen is effective as an instructional methodology.

I will provide examples illustrating how and where my techniques have worked. When this implementation system was in development, any mistakes I made were noted and resolved. The book incorporates all of these, providing you with all you require to avoid the same pitfalls when you begin your own process. Even with recent advances in manufacturing technology, manual assembly operations are still the most common form of production, and not withstanding, improvements to the areas of inventory, marketing, accounting, sales, and service are vital to becoming a world-class organization. *Kaizen Assembly* is unique because it focuses on the heart of the shop

floor and where product is made: the assembly line. This approach allows for greater detail in the subject matter and gives any engineer or engineering manager the tools needed to set up a lean assembly line. Kaizen has been around for a long time, and it has been utilized in many different ways. The book you are about to read is how I have used kaizen and the benefits that have been achieved.

It is time to take control of your assembly areas and design them to yield the results you need to stay ahead of the competition and keep your employees motivated. If you are ready to roll up your sleeves and get dirty, then continue reading and use this book to make effective long-term change on your factory floor.

Chris Ortiz
The day after leading my 100th kaizen event

Contents

Electric Bike – Kaizen Event Preparation

1

Commitment to Change

Today's company leaders face the challenge of deciding which option to take when making critical business decisions in regard to improving operational efficiency. However, when it comes to implementing a major change, the process is much simpler, with just two options to consider: operate in the current state and maintain the status quo, or embrace change. Those who embrace change propel their companies far past those maintaining the status quo. Ensuring a successful transition from the status quo is not enough: the company must fully embrace and sustain the change. In order for positive changes to be implemented and sustained, upper management must have a vision of where the company is headed, as well as provide clear direction, so that the change is embraced positively company wide. And, only companies that can successfully do this can hope to become world-class organizations.

Leaders with vision and the ability to impart it clearly and positively throughout the organization create a workforce of positive change agents. Creating this type of culture is a critical factor in realizing success and becoming a dominant force in the industry. From a strategic standpoint, the continuous improvement of company operations and processes is an absolute requirement. Since much of the company funds are allotted to the manufacturing facility, waste reductions must be identified within the facility in order to stay competitive. The reduction of wasted effort is a key factor for the manufacturing floor, and can be accomplished through the implementation of more effective and efficient production practices. A world-class organization exists primarily to provide value to its external customers. The organization's success is based upon its ability to envision its product or service from the customer's point of view, ensuring that they provide what is expected. The critical step that must come beforehand is the company's ability to engage its employees effectively by providing what they need to feel valued as well as an integral and vital part of the process. That is why it is imperative that any changes be initiated at the top, and flow downward, becoming part of the new corporate climate through the implementation of positive change management programs that engage employee interest as well as buy in. Sharing the company vision with all employees provides them with security, promoting company spirit and enthusiasm for being an active part of the new processes. Once the employees are sold on the idea, efficient

improvement programs and practices can be implemented successfully and employees will be positively motivated to manufacture quality products.

When a company is profitable, it is common for innovative-minded managers to hire additional people or purchase new equipment. A kaizen-minded manager has a different approach, knowing the value of utilizing existing talent and resources to improve productivity beyond the status quo. Kaizen means *continuous improvement*, and therefore the philosophy of kaizen is both the starting point and the driver for all lean manufacturing initiatives. Although many companies are able to implement process changes, not all are able to sustain them because of a lack of planning, ineffective execution, or an inability to foster accountability within the organization. Effective change is driven by effective change management that is initiated at the top of an organization. The kaizen program is designed to help companies create a solid foundation for change, allowing acceptance and effective integration, and thereby enabling a company to sustain the process improvements and realize the positive financial and cultural outcomes.

Change is never easy. Manufacturing professionals — engineers, supervisors, operators, and managers — are typically aware of problems that exist on the production floor and will often try to come up with creative solutions, discussing their ideas among themselves. Yet, despite all the brainstorming, solutions seldom get implemented. Typically, more than just a singular problem exists, elevating the complexity and possibly leading to a "maybe if we just did this or that" mentality. As a manufacturing professional myself, I recognize that every employee in the organization, from managers to line operators, are aware of issues, and we all seem to have a collective understanding that "things could be better." Everyone has good ideas, yet it seems to be very difficult to implement them or adjust to them after implementation. Additionally, not all ideas are valued equally. For example, an operator may try to organize his workstation in order to be more effective, but this action may be perceived as a "waste of time" by his superiors. An employee who feels that he is not a valued contributor is not likely to express future ideas or suggestions, which is a loss for the company. And, sadly, the employee may not be willing to embrace and buy in to any new process changes when they are implemented, which definitely can affect success.

Have you ever noticed how long a new idea lasts once it has been implemented? If you are operating like Company Z, then it probably does not last very long. Company Z's culture is used to creating short-term fixes and, since they have been working in that mode for many years, any deviation from the norm would probably last less than a day. Company Z works in crisis mode, therefore the concept of taking the time to analyze a problem and formulate a long-term solution is viewed as a waste of time.

Manufacturers operating with inefficient processes are not able to accurately forecast future results, and that breeds a fear of change. A volume or output mind-set prevents a company from becoming competitive in today's market because success cannot be obtained simply by getting the products to the customers. Being competitive encompasses much more, such as lower

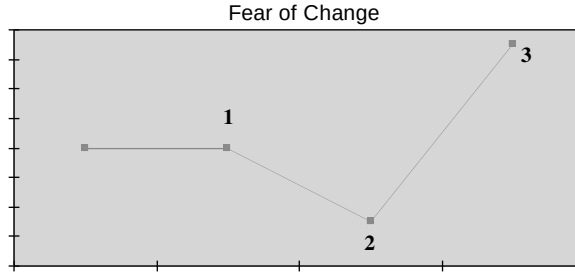


FIGURE 1.1
Fear of change.

costs, higher quality, on-time delivery, superb customer service, productivity, employment opportunities, and the creation of new products. Manufacturing is a highly aggressive and competitive industry. Companies must continuously refine their operations and lower expenses or jobs will be lost and doors will close.

Each hour of operation in a crisis-managed assembly line results in loss of money and productivity. What causes this? What is preventing success? If your assembly line is like Company Z's, you will know the answer: a lack of commitment and vision, initiated from the top and spreading downwards throughout the company like a computer virus.

Making the decision to embark on a fully organized kaizen program is a bold move. However, in my professional opinion, it is the most effective method for implementing a methodology of continuous and sustaining improvement. When every person in the organization is committed and dedicated to the policies, standards, implementations, and training components of the kaizen program, success is obtainable. However, any doubtful or wishy-washy thinking can dramatically reduce the possibility for success; therefore, upper management must create the vision and stay dedicated to its cause.

Figure 1.1 represents management's reluctance to allocate time and resources towards process improvement, which is why I refer to it as the Fear of Change Chart. This generalized chart tracks critical business metrics such as productivity, quality, volume, and revenue. Point 1 represents where the company is currently operating. Point 3 indicates the projected goal after improvements have been implemented. As the chart indicates with Point 2, there is often a dip in these metrics directly following an aggressive change in line layout, a restructuring of work content, an implementation of new standards, or improvements to existing standards. Operators and their support staff must have time to adjust to a new environment and adhere to new standards and rules. The length of time for adjustment varies depending on the degree of change, and can be as little as a couple of hours, or as much as a few weeks. Top management tends to fear this adjustment period because productivity generally falls during this time, affecting daily output, and often requiring overtime to achieve normal volume. Additionally, there

can be an increase in issues related to quality. Although all of these issues are possible during the adjustment period, adequate planning and a total company commitment to success will allow organizations to more easily tolerate this short yet chaotic time period.

The American manufacturing sector was once a strong and powerful industry. According to the article, "Manufacturing is Bleeding Jobs," published by the AFL-CIO in February, 2003, manufacturing jobs increased by 254,000 in 1997. However, by the beginning of 1998, 2 million manufacturing jobs had been lost to countries with significantly lower labor and operating costs.

In my opinion, one of the major factors contributing to this loss was the inability of American manufacturers to refine operations and processes. Adopting a more efficient and leaner approach to business would allow manufacturers to provide decent wages to their employees and avoid the necessity of using overseas labor. Inefficiency causes high levels of waste, which increases the cost of doing business and eventually will force a company to look to other countries for cheap labor. Many U.S. manufacturing jobs are already gone and more will continue to disappear unless American manufacturers begin to identify the problems within their companies and resolve them. The time to become dedicated and committed to a company kaizen program is now.

Kaizen is neither a "flavor of the month" nor a "fly by night" idea, and will not disappear simply because management or engineers are not comfortable with change. Change is displayed by our actions, not by our words. A company's kaizen program can deliver change to the production floor and become the policy for sustaining effective change as well as continuing future improvements. Complicated? No. Does it require dedication and commitment? Absolutely. To stay competitive in today's global economy, manufacturers must operate by fundamental policies that encourage and embrace change and promote commitment to continuous improvement. Companies that choose not to do this will fall behind those that are dedicated to improvement and excellence.

Operators and production supervisors will initially resist the concept of kaizen and kaizen events. Management should expect this reaction and be prepared by demonstrating their own commitment, dedication, and enthusiasm to its philosophies and the positive results that it will generate. Remember, changes can be made, but it will take strong will, commitment, and persistence to ensure that these changes are sustained. Top management must be firmly committed to the kaizen philosophy in order to train and convince employees of its benefits. Humans naturally fear change, especially after becoming comfortable in established routines, and breaking old routines and their attachments to them is a challenge that will need to be met before new processes can be implemented.

Resistance will appear in many different ways, and top management must be prepared to address resistance responsibly and sensitively. Employees should understand clearly that kaizen will not go away; that it is being

adopted and it is here to stay. This is vital because employees may have had prior experiences with new company philosophies or "missions" that were introduced and then faded away. Additionally, although ideas generated from kaizen and kaizen events will sound like a good thing, employees will not instantly buy in. They will be skeptical of something that looks good on paper or on a computer and will probably doubt its effectiveness in a real situation. From personal experience I realize that operators and production supervisors do not like being analyzed or asked to do things they are not familiar with. "Don't fix it if it is not broken" will be heard throughout the factory floor. Basically, people do not want to be told what to do, especially when they have been performing a job for many years. Effective change management must be applied to break down preconceived notions, negativity, fear, or any other form of resistance. Once that objective is met, and employees buy in, kaizen will be applied to ensure that improvements are successful.

I have been actively practicing lean and kaizen my entire career. It has been my responsibility to provide assembly line employees with the necessary tools, training, and support to ensure their success. As Masaaki Imai states in his book, *Gemba Kaizen: A Commonsense, Low Cost Approach to Management,* "Employees are separated into two categories: those who generate money and those who don't." Simply put, there are those who add value, and those who do not. Simply stated, employees working on the assembly line, the brake press, the weld and paint booths, or who are spot welders are adding value to the company. They build the product that is being sold for profit that generates money to pay them. Employees with titles such as president, vice president, plant manager, production manager, quality manager, manufacturing engineer, design engineer, etc., are considered no--value-added employees. This does not imply that they are not valuable and beneficial to the company, but simply identifies them as individuals that do not directly affect product volume. In other words, these individuals could stop coming to work and product would still get made. Conversely, if the line operators all decided to stay home, manufacturing would stop, product would not be made, and profit would be lost.

I recommend that the initial area of change be the manufacturing process on the production floor. Today's managers seem to have an innate fear of the factory floor and often think of it as a breeding ground for company problems. I believe that upper management, and even company presidents, should walk the production floor daily, observing the activity, rather than staying confined in their offices studying and creating charts and reports to illustrate factory problems.

When I was hired as an industrial engineer for a company in Burlington, WA, I was initially placed on the assembly line to help build product. Being a world-class operation, they realized the importance of employees, especially managers, supervisors, or influential engineers, being familiar with the real-life activities on the production line. Experiencing the line firsthand gave me a more complete picture, and a better understanding of the typical issues, which enabled me to be a better engineer.

Dedication and commitment to change is essential and should be addressed on the production floor first because that is where true cost savings can be achieved. A company with well-defined support departments but poorly run and inefficient assembly lines or other manufacturing processes cannot hope to be competitive in today's market.

In short, if you want to drive your company towards success and profitability, becoming a world-class organization, set the vision, make the commitment, and dedicate the company to developing a long-term, comprehensive kaizen program.

Chapter Summary

- Change must be initiated from the top of the organization and flow downward, becoming part of the new corporate climate.
- Leaders with vision, and the ability to impart it clearly and positively throughout the organization, create a workforce of positive change agents.
- A world-class organization exists primarily to provide value to its external customers.
- Companies must continually refine their operations and lower expenses or jobs will be lost and doors will close.
- Top management must be patient during times of change to allow employees to adjust to a new way of working.
- Resistance to change will appear in many different ways, and top management must be prepared to address resistance responsibly and sensitively.
- Set the vision and dedicate the company to developing a long-term kaizen program.

2

The Company Kaizen Program

Before your company can dedicate itself to making changes on the production floor through an established kaizen program, it is important to have an understanding of kaizen and kaizen events.

Kaizen

Kaizen is a Japanese word that means continuous improvement. This philosophy of continual improvement emphasizes the importance of involving employees at every level of the organization. This philosophy assumes that our everyday life should focus on constant improvement efforts. This is so natural and obvious to many world-class organizations that they sometimes forget they possess it. Kaizen is intended to be integrated into the normal day-to-day activities with the focus on eliminating waste, creating standards, and having a clean, organized workplace. Improvements made through kaizen are generally small and subtle; however, their results over time can be large and long lasting. I feel that it has been a major contributor to the economic and competitive success of the companies I have helped.

Manufacturers should be constantly thinking of where improvements can be made. The success of kaizen comes from its people and their actions, not from new pieces of equipment and machinery. American management almost worships this idea of buying innovation and using the latest and greatest in management techniques. This type of mentality will not promote a sense of continuous improvement like kaizen can.

Kaizen Events

The focus of this book will be to show how you can incorporate kaizen events into your company kaizen program. A kaizen event is different from kaizen

as a philosophy. Kaizen events are sometimes referred to as rapid improvement events. Kaizen events involve small groups of individuals in the company that are brought together to address a particular area of the company. Unlike the usual day-to-day kaizen activities, a well thought out kaizen program encompassing monthly kaizen events can reap extensive rewards for the organization.

Many organizations utilize kaizen events but still cannot create a culture that embraces change, and many improvement efforts fall short of their cultural and financial goals. The reason behind this is that the company did not have a program or policy in place to keep the employees involved, accountable, and more importantly, wanting more. Kaizen events can become a nuisance to employees if the events are unorganized and under management that does not believe in their cause. Management must set clear targets to guide everyone and make certain to provide leadership for all kaizen activities directed towards achieving those targets. Real kaizen strategy at work requires closely supervised implementation.

First, top management must devise a long-term strategy for conducting kaizen events and provide the tools necessary for the kaizen teams to be successful. Kaizen events without vision and focus are like road trips not having a final destination. Kaizen events are most effective when everybody works to achieve that vision. Here are the key ingredients in establishing your company kaizen program.

Kaizen Program

Create and Communicate the Vision

Ever heard of flavor of the month? This is an infamous statement in manufacturing that represents an organization's inability to adhere to new standards or ideas and they fade away after a short time. This does not necessarily mean that the ideas were bad; it failed because it was not supported from top management and operators were allowed to deviate from what was put in place. It is critical to your company to create the vision and believe that a newly developed kaizen program is the company's way of doing business.

Since many operators are familiar with the flavor of month or some grand short-term fix that will not work in the long term, it is vital in the beginning stages that the vision comes from the highest position possible. Referring back to my earlier days with Lennox Hearth Products, the company never had motivation to implement kaizen and redesign the assembly lines until we heard it from the vice president of domestic operations. The vision had been set for all the plants in the country. It was made very clear at that point

that, "We are doing kaizen." More importantly, we were to start on the assembly lines.

Establish the Kaizen Champion

A successful kaizen program should have a person who is 100 percent dedicated to the planning and execution of the kaizen events. It is my professional opinion that the employee for this role should not be in top or middle management. They should possess the proper project management and supervision skills that will be needed during kaizen events; however, I recommend that they stay away from the daily requirements of management. An ideal candidate for your kaizen champion would be a lean manufacturing engineer. It is safe to default to an industrial engineer or manufacturing engineer; however, someone with solid lean skills and an understanding of 5S (5S is a cleanliness and organization philosophy of removing unnecessary items from an area, organizing what is left, and creating an effective system to monitor the program), kaizen, and standard work will help drive the program and ensure success during kaizen events. A kaizen champion is essentially a continuous improvement "manager" driving the lean initiatives in the company and helping keep top management accountable for providing the support needed. I have seen very aggressive kaizen champions that were not afraid of being very direct to plant management when it came to planning and executing kaizen events. As long as the kaizen champion's approach is diplomatic, he can be highly effective for a company.

Communication Boards and Newsletters

Thorough communication will make all the difference in whether a kaizen event will succeed or not. An announcement from the top will communicate that serious support is given for the event. Posting the schedule and outlining all the steps will help employees become familiar with what to expect and will reduce doubts or fears about the unknown. Post descriptions of what will happen during the kaizen event and the overall plan. Let everyone know what lines will be affected and what the benefit will be.

Your newly appointed kaizen champion should first start working on developing the communication system that will deliver kaizen and kaizen event information to all the employees. The use of communication boards can be very effective. Plants vary in size, so identify areas where information boards can be placed in break rooms or meeting areas, or select a central location in the plant that can be used to communicate the upcoming kaizen events. It is best to use a dry erase board because the information may change daily, weekly, and monthly. This communication board should only be utilized for kaizen and kaizen event related information. Do not clutter it with other data. By creating a dedicated kaizen event communication board, you

Kaizen Communication Event Board

Kaizen Event	Week	Leader	Members
Electric Bike Line Standard Work	Week of 12-11-06	Ryan Brown	Bill Jones Rita Smith Tina Stuart Paul Phillips Tony Felton

FIGURE 2.1
Kaizen event communication board.

show the production floor the dedication towards the kaizen program. The kaizen champion is responsible for maintaining this board as events are scheduled and completed (see Figure 2.1).

The next step is to communicate the day-to-day kaizen activities that the company is conducting. A very effective approach is to create a company newsletter that is published every month. Human Resources should be responsible for maintaining the newsletter on a continual basis, but the kaizen champion should provide the necessary information. The newsletter should have information on the continuous improvements efforts that are going on in the plant. Employee names, the changes, dates, and the reasons the improvement was needed should be in the newsletter. The company newsletter should have a section that looks similar to the kaizen event communication board detailing the upcoming kaizen events scheduled for the plant floor. It is important to remember the difference between kaizen and kaizen events.

Another effective way to communicate ideas for kaizen events is a kaizen suggestion box. A suggestion box is a great tool to allow operators to communicate to management about areas on the production floor that could use a kaizen event. Although operators should be participating in kaizen in a daily basis, they may come across areas in need of waste reduction, 5S, or standard work that they cannot resolve during the day. They can simply fill out a small form and place it in the box for future discussion. The kaizen suggestion box should be located near the kaizen event communication board. The kaizen champion is responsible for collecting the suggestions every week and considering the ideas for future events.

The Kaizen Governing Committee

Another vital element of the kaizen program is establishing a committee of employees to help schedule and watch over the monthly kaizen events that will take place. This kaizen governing committee is responsible for

ensuring the success of the kaizen teams and to help clear any obstacles or constraints that would impede the improvement efforts. Since you have already identified the kaizen champion, this committee only meets one time a month. It is the responsibility of the kaizen champion to ensure that the hands-on work during kaizen events is getting done. If there are any issues that need to be resolved from a management perspective, then the kaizen governing committee must resolve them. Kaizen governing committee members should include:

1. The kaizen champion
2. The plant manager
3. The production manager
4. The engineering manager
5. The materials manager
6. The quality manager
7. The facilities/safety manager
8. The human resources manager

I realize that, due to varying staff sizes, a company may not have people in all of these positions. This is an ideal situation, and you will have to adjust accordingly. Let me explain each committee member's role to help in selecting who in your company will be on the committee.

Kaizen Champion

The kaizen champion is responsible for conducting the meeting and tracking the kaizen events. Although kaizen is continually happening, this person will deliver all the necessary information on prior and future kaizen events. The kaizen champion should develop the budget and expected savings for each event. This information should be given to the plant manager and the other committee members. More than likely your kaizen champion will lead the majority of the events, so he or she will have detailed knowledge of the activities.

Plant Manager

If your organization's highest position is a plant manager, then that is who is required to attend all the kaizen governing committee meetings. This should be one of the most important meetings a plant manager attends. Since this person initially sets the vision and focus, his presence in the meeting is critical to any kaizen program. Along with the kaizen champion, he is respon-

sible for keeping the other members on the committee accountable for contributing their people, resources, and time to the kaizen events. Plus, the plant manager simply needs to know the areas being addressed on the factory floor.

Production Manager

Sometimes called the operations manager, the production manager plays a vital role on the committee. One of the aspects of kaizen events is that all team members placed on the event are 100 percent dedicated to the project, and their ordinary daily responsibilities are given to someone else of equal or greater talent. Since all kaizen teams will include operators and other employees from the production floor, the production manager needs to commit those individuals and ensure that their work on the line is covered. Also, the production manager will be involved in the eventual training of their operators after the assembly lines or processes have been changed. This is generally a tough position to be in because they will have to supervise the daily production efforts while the kaizen team is on the floor making changes. And in many cases the team will be physically moving stations and machines while the operators are assembling final product.

Engineering Manager

Your kaizen champion should report to the engineering manager. The engineering manager should be a strong ally of the kaizen champion. This person allows the kaizen champion to stay focused on the kaizen efforts and the scheduled kaizen events every day. The kaizen champion should be allowed to make many decisions on their own with the support of the engineering manager. The kaizen champion and engineering manager should be in continual communication on the directives and initiatives driven by the kaizen champion. Although there may be disagreements from time to time, these two people should have the same focus.

Materials Manager

As the assembly line changes are made, parts will be moved and various forms of material will be needed. The materials manager is responsible for providing the necessary manpower from his department. Also, certain kaizen events will require purchasing equipment, supplies, and material like shelving and part bins. It is hoped that, after an aggressive 5S campaign, there will be little need for extra material and supplies. However, new items including bins, shelving, visual management supplies, and other necessities to construct the assembly line may be required.

Quality Manager

Since all kaizen events that address assembly line layout will involve analyzing work content and establishing or revising standard work, the quality manager must commit a representative from his group to the team. As work content is shifted and new standards are created, a quality person should help identify the important quality responsibilities that will follow the work instructions and standard work changes. There may be a need for new measuring devices and testing equipment. The quality manager will also participate in the training efforts along with the production manager after implementation has been completed. Finally, as parts are moved around and locations are established, there may be a need to look at part protection to help avoid scrap and rework costs.

Facilities/Safety Manager

During kaizen events, workstations, equipment, machines, testing equipment, computers, and tools may be relocated. The facilities department is responsible for helping disconnect and reinstall any and all wires, pipes, cables, and air lines needed to support the move. Many facilities managers have safety responsibilities in the plant as well. It is important, no matter how important the kaizen event is, that employees are working in a safe manner to avoid injury. This includes providing adequate security if the team is working in the evening, that forklifts are used to help lift heavy objects, and that the required safety protection is being worn. Items that have been moved around should be secured to the floor once a permanent location has been identified. The facilities manager must provide the necessary resources to the kaizen team to prevent the team from being stalled by the inability to move and install a machine or equipment. In all cases the kaizen team has to decide on a stopping point at the end of each day, and the facilities department has to make sure the assembly line can run the following day.

Human Resources Manager

The human resources manager is responsible for all employees in the company. This person needs to have a general understanding of the work that the employees will be doing and the hours that are going to be worked. The human resources manager should work alongside the other managers on the committee to verify that employees picked for the team will not be on vacation or gone from the plant during the event. Also, the human resources manager will be actively involved in the training of the operators and keeping track of all documentation related to training.

As you can see, the kaizen governing committee is made up of managers and the kaizen champion. All kaizen activities should involve associates

from the production floor; however, this committee is in essence an administrative team for the kaizen program. Attendance is critical to the meeting's proceedings, and if a committee member is unable to attend, then a qualified representative from his department should participate to help make the important decisions.

Kaizen Team Selection

One of the fundamental aspects of kaizen is the participation of employees from all levels of the organization. Many companies fail to recognize the importance of utilizing the production operators in making decisions. An operator being pulled from the line is considered taboo because it is seen as removing valuable resources from building product. You will see later in this chapter how the proper planning of your kaizen events and the use of operators will not effect production.

Your kaizen program should be an ongoing corporate practice so that at some point every employee in the company has been on a kaizen event, including plant managers and presidents. However, you should create a kaizen team selection criterion that identifies the important job titles to ensure a successful kaizen event. As mentioned before, when establishing the kaizen governing committee, your company size may not allow you to have the ideal team. Below you will find a kaizen team selection criterion that has been very successful for me and you can adjust as needed depending on your staff. Remember, the goal of your team is to implement 5S, standard work, reduce waste, and create visual management. Based on these key kaizen philosophies, your team should involve the following members.

Team Leader

All kaizen events should have a team leader that understands the critical aspects of kaizen and how to successfully lead a team. Since your kaizen champion should have a background in 5S, standard work, waste reduction, visual management, and project management, he or she is the ideal leader. Past experience has shown me that the kaizen champion should lead the majority of the kaizen events. However, your kaizen governing committee should decide when another person should lead an event. As a general rule, I appointed an employee to be a kaizen event leader after they had participated in five kaizen events. By then, they had proven to me and our kaizen governing committee that they understood all the necessary skills to lead an improvement team.

Team Members

Process Engineer

Depending on the assembly line or area that has been selected for the kaizen event, the process or manufacturing engineer that is responsible for that line should be on the team. They hold detailed knowledge of the product line, the training levels of the operators, the current assembly process design, and the proper work sequence.

Quality Engineer

Not all companies have dedicated quality engineers assigned to particular areas. Many quality engineers have responsibilities all over the plant. However, a quality engineer or a highly skilled quality technician should be on every team. As I mentioned before, work content may be shifted, standards will be improved or added, and work instructions will need to be updated. The quality engineer needs to help supervise and oversee these changes and provide feedback on what quality issues could arise from the changes. Material presentation will more than likely be altered and improved, and the quality engineer can help with part protection. Your quality engineer or technician will be able to generate metrics for reject, scrap, and other quality indices from that line and find ways to implement quality standards to reduce those occurrences.

Facilities/Maintenance Personnel

An important member to any kaizen team is a facilities person. These people are critical in helping the team finish on time and avoid creating delays for the assembly line the following day. Machines, equipment, workstations, tools, and other items of an assembly line will be moved around while the line is constructed. Your facilities person will ensure that everything is operating and properly secured to the floor. He understands the electrical, plumbing, compressed air, network lines, and power systems of the facility.

Materials Handler

Every kaizen team should have a materials operator who is assigned to the assembly line. This individual works on the production floor to provide the assembly line operators with parts to build products. He has a good understanding of part sizes, and this information can really help the team decide on material presentation to the workstations. A materials person will know which parts are heavy and difficult to handle, and can assist the team in establishing delivery frequencies.

Line Operators

The most important team members to any kaizen team are the operators that work day in day out on the assembly line. They hold the detailed knowledge of the product, the assembly line, tools, fixtures, machines capabilities, daily issues, and other important aspects of the line that only a person working in the workstation would know. The operators on the team should be used at every step of the analysis, design, and construction phases. More importantly, they will be critical in helping train and change the culture on the assembly line after the changes have been made. The other operators will respect the fact that "one of their own" was part of the team. Two operators from the line should be on the team.

Management

Every kaizen team should have top managers as members. Plant managers and presidents, if possible, should roll up their sleeves and get dirty alongside everyone else. This will show the commitment of the company to the success of the kaizen program. Your organization should make it a requirement that each member of the kaizen governing committee and other managers be involved in kaizen events.

Success of the teams relies on the company's dedication and commitment to the goals established through the kaizen program. Human Resources should document which employees have been involved in kaizen events, and a minimum requirement should be set for kaizen event participation. You may want to consider an incentive program to encourage frequent participation for those who show a passion for change. After a few kaizen events have been completed, you will start to identify those individuals who have proven themselves as change agents and those who have not. A secret list should be created by the kaizen governing committee of those employees who have been avoiding being placed on kaizen teams and, when they have been on a team, contributed very little. The success of each event depends on the team members' dedication to the project, and it only takes one person to slow down the proceedings. Future employee evaluations should include kaizen team and kaizen contributions.

Kaizen Event Tracking System

The next piece of the kaizen program is how your kaizen governing committee tracks the kaizen events. You need to develop a kaizen tracking system.

Kaizen Tracking Worksheet

The kaizen tracking worksheet is used by the kaizen governing committee to monitor and track kaizen events. Using Microsoft Excel™ as the program base, the kaizen tracking system is a great tool for keeping up on all kaizen events and helping teams complete their objectives. There are 14 fundamental categories that should constitute your kaizen tracking worksheet (see Figure 2.2).

1. Kaizen event
2. Team leader
3. Team members
4. Date and length
5. Strategic purpose
6. Anticipated results
7. Preplanning
8. Estimated cost
9. Event spending
10. Actual results
11. Action items
12. Due dates for action items
13. Responsible
14. Status

Kaizen Event

This category is used for selecting the assembly line or area for the next kaizen event. There are certain rules that should be applied when selecting the kaizen event.

All kaizen events should be scheduled at least one month in advance.

Kaizen events should be held on the same week of the month every month. In the last two years I have used the fourth week of every month. Consistency is good practice because after a few kaizen events the employees become accustomed to kaizen events and they know that every fourth week the company will be conducting an event.

Areas chosen for kaizen events must warrant the need. I believe there is always room for improvement, and I have conducted kaizen events in the same areas three times in one quarter. Does the area have excessive WIP (work in process)? Is there a problem with flow every day? What kind of productivity is coming from the line, and is the area a mess? Make sure that the changes made to the area will positively affect the overall operation of the plant.

Kaizen Event Tracking Worksheet

Kaizen Event	Date/Length	Team Leader	Team Members	Strategic Purpose	Anticipated Results	Actual Results	Pre-Planning	Cost	Event Spending	Action Items	Responsible	Due Date	Status
Motor Line	Week of 4-25-06	Kyle Turnbull	Peter Brown	Improve Productivity	20%	25%	Time Studies	$ 500.00	$ 225.00	Finish Labeling Part Bins	Ryan Faith/Jeanette Tyler	05/11/2006	Complete
			Jeanette Tyler	Reduce Floor Space	30%	30%	Verify Vacation Schedules			Install Motor Fixture	Jennifer Rogers	05/18/2006	Complete
			Roger Thompson	Reduce Travel Distance	35%	25%	Service the Forklift			Remove Red Tag Items from Storeroom	Leonard Michaels	05/18/2006	50% Complete
			Ryan Faith	Reduce Work Stations	30%	35%				Finish Taping Floor in Station 2	Roger Thompson	05/23/2006	-
			Leonard Michaels	Reduce Scrap	15%	20%				Purchase and Place Production Control Board	Peter Brown	05/24/2006	Board Ordered
			Jennifer Rogers										
Electric Bike Line	Week of 12-11-06	Ryan Brown	Bill Jones	Improve Productivity	20%		Time Studies	$ 750.00					
			Rita Smith	Reduce Floor Space	40%		Verify Vacation Schedules						
			Tina Stuart	Reduce Travel Distance	40%		Reserve 3" Drill						
			Paul Phillips	Reduce Work Stations	35%		Order Part Bins						
			Tony Felton	Reduce Scrap	15%		Order Antifatigue Mats						
							Order 1" Tubing						

FIGURE 2.2
Kaizen tracking worksheet.

Team Leader

As stated before, your kaizen champion should lead most kaizen events. For some reason you may have to select another employee instead of your kaizen champion because of vacations or business travel. Team leaders should be chosen the day that the kaizen event has been selected.

Team Members

The kaizen governing committee should select the team members two weeks prior to the event. This is extremely important because all team members must be present for the kaizen event. Using the kaizen team selection criteria, the committee should be able to find out who is on vacation, traveling, on sick leave, short-term disability, or who may be involved in a project that requires his or her participation. This also allows the members to prepare for the event and meet with their managers to make sure their duties are covered during the event. Team members can also plan their nonwork activities with families and friends because the committee may decide that the team needs to work on an off shift. Proper planning of the team members will help ensure success for the team. Lack of team participation will hurt the team during the event.

Date and Length

As mentioned before, kaizen events should be scheduled four weeks in advance at every kaizen committee meeting. Kaizen events are typically five days in length. However, I have lead events lasting two days or four weeks, depending on the complexity of the assembly line or area. The kaizen governing committee should schedule the events keeping in mind other important initiatives going on in the plant. Select the week and length of the event and stick to the plan. Do not change the date at the last second.

It can be very challenging to conduct a kaizen event when the operators are still working. Try to plan the event for off hours. If the assembly line works first shift, then schedule the event during the hours of a second shift. I have led many events that started at 2:00 p.m. and lasted until 10:00 p.m. Team members were not required to come in until 2:00 p.m. and they worked without disturbing the line. Working during graveyard hours is also an option, but there can be safety issues. Just make sure the team is aware of the change in hours so they can properly prepare.

Strategic Purpose

Each event should be selected based on its contribution to the key business metrics. There are seven business metrics that should be addressed during an assembly line kaizen event.

1. Productivity improvement
2. Floor space reduction
3. Station reduction
4. Travel distance reduction
5. Quality
6. Work in process (WIP) reduction
7. Inventory reduction

Through the implementation of 5S, standard work, and visual management, these seven metrics should be impacted in a positive way. On rare occasions, floor space and travel distance may increase because a team's strategic purpose could be to increase volume even after a successful waste reduction campaign has been done. However, if these seven metrics are improved, your kaizen team will be very successful in improving the company's bottom line.

Anticipated Results

The kaizen governing committee needs to come up with what the percentage of change will be for the seven metrics after the event is complete. This should not be an exact science because at this point these results are estimates. The kaizen team simply needs a target to shoot for, and their efforts should be centered on achieving those results at a minimum. It is safe to be aggressive when estimating these results. The purpose of having kaizen events is to break through obstacles and help the company; so a little challenge is healthy.

Preplanning

Most kaizen events require some initial work up front to prepare for the project. I firmly believe that a preliminary analysis of the assembly line should be done. For example, time and motion studies should be completed or be close to completion prior to the event. However, there may be other preplanning items that could arise. Contractors may need to be scheduled to help with construction. The team may require special equipment and material for the event, and reservations and deposits may be needed. The kaizen team could need supplies including tape measures, floor tape, paper, etc. Make sure these items are identified for the appropriate committee member.

Estimated Cost

One fundamental aspect of kaizen is the belief that improvements can be made with little or no money. However, it is good practice for the kaizen champion or team leader to develop a budget for the kaizen event. I have

seen budgets for events ranging from $20 to $5,000. This money is used for many things or may not be used at all. It is good to have a budget and the money set aside for the team.

Event Spending

It is good practice to keep up with money spent on each kaizen event. Compare the estimated cost and the actual amount spent for each kaizen event. At the end of the year, the kaizen champion can add up the total amount spent and compare it to how much was originally budgeted. In most cases, there is a big difference, and as the kaizen teams refine their approach to kaizen events, less and less will be spent.

Actual Results

After the kaizen event has been completed and the assembly line operators have had time to adjust to their new surroundings and procedures, it is important to document the actual results. Ideally, the actual results should be greater than or equal to the results estimated prior to the kaizen event. There are few occasions when the team's efforts fall short of the desired goals. It is important to realize this is not a failure on the part of team; it is just a reality of kaizen events.

Action Items

Rarely does a kaizen team complete every task during the kaizen event. Minor disruptions to the schedule sometimes occur, pushing items further into the week. Plus, the team will more than likely come up with additional improvement ideas that cannot be completed before the end of the event. Each team leader should put together an action item list from the event. This is generally called a 30-day mandate. All action items from the event must be complete within 30 days from event completion. Thirty days is a legitimate length of time for the members to complete unfinished work after returning to their usual responsibilities. It is important to wrap up loose ends from the events to ensure proper closure to the project.

Due Dates for Action Items

Although there is a 30-day mandate, many action items do not require much time to finish. During that 30-day window, set dates for completion of the unfinished work. This allows the kaizen governing committee to keep track of where the team is and to hold them accountable for not completing their work. There may be instances when a team member is unable to complete his action item due to circumstances beyond his control. The committee is responsible for clearing any obstacles for the team member and creating new due dates within the 30 days.

Responsible

Every team member must be assigned to an action item. If there are less unfinished items than there are team members, double up on people. If there are more unfinished items than there are team members, the kaizen governing committee should assess the items and decide who will get the work and if the 30-day mandate should be extended. The kaizen event is truly complete when all action items have been finished as a team. Make sure to assign the action items based on the team members' skill sets and schedules. Do not expect an operator going back to the assembly line to work while also required to finish fabrication of a new kaizen event fixture.

Status

It is important to track all the action items to completion. By updating the status of the items at the kaizen committee meeting, everyone will know where everything stands and when the kaizen event is truly complete.

Kaizen Monthly Meetings and the Kaizen Event Supply Box

At this point you have selected your kaizen champion. The communication system has been established to convey important kaizen and kaizen event information. You have assembled a team of managers to be the kaizen governing committee, and a comprehensive tracking worksheet has been created for administrative purposes. The final two pieces of the kaizen program are the kaizen monthly meeting and the kaizen event supply box.

Kaizen Monthly Meeting

A company that runs a well thought out, structured meeting will find that more work gets done on time. Never let a meeting take up too much time, and always stay focused on the subject at hand. The kaizen monthly meeting should take place once a month on a recurring basis. For instance, schedule kaizen meetings every second Tuesday of the month. This allows the committee members to schedule their other responsibilities so they do not forget a meeting. It is a good rule of thumb to advertise the meeting in the company newsletter, acting as a friendly reminder for everyone in the plant. The kaizen monthly meeting should be broken into three categories:

Part 1: Discussion of open action items: 15 minutes

Part 2: Discussion of the last event's results: 20 minutes

Part 3: Planning upcoming events: 30 minutes

Discussion of Open Action Items: 15 Minutes

By conducting a kaizen event every fourth week of the month and having the kaizen monthly meeting every second week, the committee can successfully discuss the prior event's action items. The team will be two weeks into their 30-day mandate and there should be updated information to discuss. Team members with action items still open are required to attend the meeting to provide information on their progress. This allows the committee to ask questions of those responsible and help the team members find ways to complete the action items. We expect that the committee will be able to close some of the open items and congratulate the team members on a job well done. This portion of the kaizen monthly meeting should take no longer than 15 minutes, and the kaizen champion should update the kaizen tracking worksheet as needed. It is good practice to use a projector or a conference computer system so the kaizen tracking worksheet can be displayed during the proceedings.

Discussion of the Last Event's Results: 20 Minutes

The kaizen governing committee should review the strategic purpose and anticipated results columns on the kaizen tracking worksheet and decide what the actual results were. If the productivity gain was estimated at 25% and it was only 15%, what was the cause? Maybe the goal was set too high or the team forgot to work on a particular item. On the other hand, maybe productivity was improved by 30% and the committee needs to discuss why. Either way, the actual results of the key business metrics should be compared to the earlier estimations. This will help the kaizen champion or team leader create better goals for the next kaizen event.

Every kaizen event has its ups and downs. The kaizen governing committee should go over "lessons learned." What happened from the prior event that can be instructive? The first item usually discussed is who was committed to the cause and who was not. Did the team members execute? Who did not execute? Another lesson learned could be that the up-front planning was not enough.

Depending on the product mix, options, or other complexities, time studies and other analyses may be needed before the kaizen team is even selected. Maybe the lesson learned was that the time studies were rushed, or that because of schedule conflicts, certain products could not be built to accommodate the analysis. Whatever the issues are, the lessons learned segment is an important aspect of the kaizen meeting.

Finally, part two of the meeting should also be about transition. The committee needs to evaluate the progress of the new assembly line and determine how the culture is adjusting to the changes. Committee members need to discuss what should be done to shorten the learning curve of the operators and to show conviction to the cause. Maybe added training is needed or new action items need to be assigned. The operators need all the support required to ensure success of the line.

Planning Upcoming Events: 30 Minutes

The last part of the meeting is to plan the next kaizen event. The kaizen governing committee should be slowly generating ideas for future events and documenting them on the kaizen tracking worksheet. From this list, the committee should decide on the next event, the team leader, team members, date and length, strategic purpose, estimated results, cost, and the preplanning. The kaizen champion, who is running the meeting, should be in charge of filling in the columns on the worksheet based on the decisions of the committee. Remember, the kaizen champion has the most say in what is scheduled; however, the committee as a whole truly decides the schedule. Again, since the committee is meeting every second week of the month, they are able to adhere to the kaizen program rule of setting teams two weeks in advance. Never at any time appoint temporary workers to the kaizen team. Although I am a firm believer that kaizen creates jobs in the long run, temporary workers may be let go because of improved productivity.

As you can see, the meeting should take roughly one hour, and it is a highly structured proceeding. The kaizen champion is responsible for running a smooth meeting and keeping the committee members on the subject matter. Take pride in this meeting and be serious about what is discussed. It should be an honor to be part of this committee and its meetings.

Kaizen Event Supply Box

All kaizen teams will require certain supplies and tools to successfully conduct kaizen events. I recommend putting together a kaizen event supply box. When implementing 5S, standard work, and visual management, there are certain items that are needed on every event. A kaizen event supply box will allow the team members to easily complete their projects during the event. These supplies should be replenished at the conclusion of every kaizen event so the next team will have them available. You will find a list of recommended supplies and tools to be included in the kaizen event supply box in the following paragraphs.

Stop watches: I am a firm believer in conducting times studies prior to the kaizen event; however, team members may be required to confirm the time study data on the first day of the event. I recommend having five stopwatches in the box.

Tape Measures: Tape measures will be used often during the entire kaizen event. Each team member should have a tape measure, so have around seven 25-ft tape measures in the box. It is also smart to have a 100-ft and a 300-ft tape measure for longer distances.

Floor Tape: The kaizen governing committee will decide on the appropriate colors for floor designations. Since 5S requires all items on the floor to be identified, the kaizen event supply box should have a minimum of five rolls of tape. There are dozens of industrial supply companies that offer floor tape in a variety of colors and patterns.

Double Stick Tape: Double stick tape can be useful for ensuring that floor signs are secure to the floor. Double stick tape is essentially carpet tape, and can be found in virtually any home improvement store. There will be situations that arise that the only way to secure signs and labels is through the use of double stick tape. I recommend having three rolls in the supply box.

Knives or Box Cutters: Each team member should have a cutting device with him. The best way to cut floor tape is with a box knife of some kind. I recommend having seven box knives in the supply box.

After your organization has conducted a few kaizen events, other supplies will be identified and added to the inventory list. Place an inventory list on the kaizen event supply box so the kaizen champion can easily reorder items after every kaizen event. This supply box should be locked when kaizen events are not taking place.

Along with the kaizen event supply box, your company should invest in a laminator machine and the appropriate laminating material. It is good practice to laminate all signs, labels, banners, posters, etc. They will last longer and that will help reduce the cost of replacing them.

So, there you have it. A company kaizen program is essentially a policy for creating and sustaining improvement efforts in the company. By following the guidelines set forth in this chapter, you can create a solid kaizen program and start planning kaizen events for your factory floor.

Chapter Summary

- Kaizen is a Japanese word for continuous improvement and emphasizes the importance of involving all employees in the company.
- Kaizen events involve small groups of people in the company brought together to address a particular work area.
- A company kaizen program helps create a foundation for creating and sustaining positive change in an organization.
- Establish a kaizen champion who is 100 percent dedicated to planning and executing kaizen events. The kaizen champion drives the lean initiative in the company and keeps management accountable for providing the support needed.
- Develop communication boards and a newsletter to communicate kaizen and kaizen event related information.
- Establish a kaizen governing committee to oversee the kaizen program. This committee is responsible for ensuring success of kaizen event teams and for clearing obstacles or constraints that would impede the improvement efforts.

- Use a kaizen tracking worksheet to monitor and track the kaizen events.
- The kaizen governing committee meets once a month to evaluate the progress of the kaizen program and plan kaizen events.
- Put together a kaizen event supply box for items that will be used during every kaizen event. The kaizen champion is responsible for keeping up with the supplies and having them available prior to all events.

3

The Basics

The Seven Wastes, 5S, and Standard Work

At this point you have done far more than most companies have. Recognizing the importance of developing a comprehensive kaizen program is a positive step, which will not only improve your manufacturing processes, but will also effectively create a new company culture, rich with change agents. As you can see, establishing the kaizen governing committee and creating the kaizen tracking worksheet are relatively easy tasks. However, before you can begin conducting kaizen events, all employees in your company will need some knowledge and understanding of basic lean philosophies and terminology. This chapter contains the essential information each employee needs in order to be an engaged participant and an effective contributor in kaizen events and activities. As kaizen events are scheduled and teams are selected, training should occur. You should train the kaizen governing committee first, and then the team of employees selected for the first scheduled kaizen event. Lean management in mind, it is likely you will take my suggestion and begin kaizen with the assembly line and the line operators. But, at some point, the company will require all employees to participate in a kaizen event, and they all will need this training. So let's begin.

The Seven Wastes

The seven wastes were initially identified almost 50 years ago by Taiichi Ohno during the development of the Toyota Production System. Waste exists at every level of the organization. The training should begin by providing employees with a basic understanding of the seven wastes. There is one additional waste, which is one of the most destructive, and I will discuss it later in this chapter. For now, let's just focus on the first seven.

1. Overproduction
2. Wait time

3. Transportation
4. Overprocessing
5. Inventory
6. Motion
7. Defects/rejects

Only two types of work activities exist in manufacturing: value-added work and no-value-added work. Value-added work is defined as work that the customer is willing to pay for. An operator placing parts into a product on the assembly line is an activity the customer cares about. However, if the operator has to walk ten feet to a shelf, spend two minutes searching for parts, walk back to the workstation, and then stumble around looking for the appropriate tool, this costs the company money that the customer will not pay for. I will now break down the waste into individual parts, indicating the time utilized for each.

Walking to the shelf:	10 seconds
Searching for parts:	120 seconds
Walking back to the workstation:	10 seconds
Searching for tool	15 seconds
Installing the part:	5 seconds
Total Time	160 seconds
Total value-added time	5 seconds
Total no-value-added time	155 seconds

This is a very simple example of wasted movement and time, but it is quite an eye opener. If the inefficient process is allowed to continue, it will result in the accumulation of no-value-added work, which is not covered in the price the customer pays for the product, and therefore increases your production costs. I will show you ways to eliminate this type of waste later in the book.

Overproduction

Overproduction is probably the most common form of waste in a manufacturing environment. Producing more than is needed, faster than necessary, and before it is needed, is a dangerous practice. Batch processing or building ahead can create problems for the assembly line. The fear of absenteeism, potential machine breakdowns, anticipated rework and scrap, and "not looking busy" will generally cause operators to overproduce. Line supervisors and managers cannot always control absenteeism and employee turnover, and will build product ahead of schedule just in case they are short on employees the following day.

Many companies either have a poor preventive maintenance program or continually purchase equipment that is cheap and unreliable. Rather than fixing the equipment issues, operators prepare for possible equipment malfunctions by producing more product than is required, "just in case." Typically, the same unreliable machines are unable to yield the required tolerances for fit, form, and function, so rework and scrap become standard procedures. The plan of record is to build extra product now, while things are under control, just in case they get out of control. In most manufacturing plants, it is common for the line supervisor to watch the line work their entire shift. This constant scrutiny causes operators to feel insecure so they tend to keep working whether or not it is necessary. The negative results caused by overproduction are the accumulation of excessive work in process (WIP), the hiding of quality errors within that WIP, inaccurate output counts, high labor hours, and poor use of inventory. Basically, product is being manufactured when it is not needed, requiring more material to be purchased at the wrong time. Overproducing creates unnecessary finished products that simply pile up in finished goods inventory. The closer you can get to single piece flow, building when needed, and knowing when to stop, is the ideal situation.

Wait Time

Waiting occurs when all manufacturing processes are out of synchronization, causing an operator to be idle. Lack of parts, work content imbalances, inaccurate standards and methods, long setup times, bad equipment, poor communication, and rejects all create wait time. Whether an operator is installing a part or waiting for that part to arrive at their workstation, you are still paying them. I have personally witnessed wait times exceeding two hours due to unreliable machinery and communication systems that were unable to efficiently inform the maintenance department of issues on the line. In these cases, volume was significantly reduced, requiring operators to work the following Saturday to make up the difference. This cost the company a lot of expenses in overtime hours and operation costs, as well as abused employee personal time with their families for that weekend and part of the following work week.

Transportation

It is important to note the domino effect that results: one waste will create another. Overproduction will cause wasted transportation. As mentioned previously, building product beyond requirements creates false indicators in inventory control that stimulate the movement of material out of inventory unnecessarily. Material movement requires manpower, forklifts, paperwork, and, of course, money. Wasted transportation will also contribute to inaccurate inventory counts, excessive material storage, and damage to parts during transit. I witnessed this exact scenario while conducting a kaizen event

at my second place of employment. An operator built more wire harnesses than were required for that hour's production. The worker next to her built the exact quantity required of a different model of wire harness. The operator who was overbuilding signaled for more material, so she could keep producing, which falsely signaled the materials handler to retrieve more parts. While this was occurring, the operator building to the required quantity ran out of parts, but the material handler was unavailable to supply them. This entire situation was caused by overproducing, and it wasted transportation and resulted in undesired wait time.

Wasted transportation can also be caused by poor planning and scheduling. Inefficient plant layouts in which material handlers have to walk long distances to locate parts and deliver them back to assembly lines is another cause of wasted transportation.

Overprocessing

Overprocessing is similar to overproduction in that it is redundant effort adding no value to the product. Overprocessing is common in a fabrication department where sanding, polishing, grinding, and deburring, for example, can be overperformed.

Part protection is another activity where overprocessing can occur. Protecting parts repeatedly may seem to be a good approach to scrap reduction. However, packaging and unpackaging of a part repeatedly is overprocessing. For example, a circuit board may be unpackaged from a bag that came from the supplier. It is worked on by the operator and then repackaged to protect it while in storage. The next operation retrieves it and it is unpackaged again to be installed on the main assembly line. A protective bag is placed over the circuit board and secured with a rubber band to avoid damage as it travels down the assembly line. Finally the part arrives at the final testing station, where the protective bag is removed. Overprocessing is not always necessary, and at some point it can become wasteful and redundant. All of the unpacking and repackaging can be avoided by simply placing the circuit subassembly station next to the final product testing station, so that the part can be handed directly to the test technician.

Inventory

If you want to significantly reduce cost in your facility, reduce the amount of wasted inventory. Excessive inventory is generally associated with what is kept in the storeroom. Most companies hold much more than is needed due to inefficient processes on the production floors and unreliable inventory control software. It is important to accurately assess the rate at which operators build final product and subassemblies, as well as the appropriate length of the assembly line to ensure efficiency. Assembly lines that are longer than necessary will breed excess WIP. For example, a line may only require five workstations to perform the task, but due to the sheer length of the line, may have as many as

fifteen units piled up. The operators can only work on five units at one time; therefore, the remaining ten units become wasted inventory. If the units cost approximately $5,000 apiece, then there is $50,000 wrapped up in wasted inventory. This wasted inventory is a result of overproduction and overprocessing. Remember, one waste will create another waste: the domino effect.

Manufacturers also make the common mistake of permitting operators to build more subassemblies than needed. For example, let's suppose the daily manufacturing requirement is to build 25 printers throughout the day: no more, no less. If an operator does not have sufficient training, direction, or a clear signal to stop building printers and begins building another subassembly, the operator is likely to continue building printers, which produces waste. And, as mentioned previously, this overproduction creates false signals to inventory control, causing more parts to be ordered unnecessarily.

Motion

Nothing bothers me more than wasted motion. If an operator has to move more than a few steps for a part, I immediately implement kaizen. Wasted motion is any movement that does not add value to the product. Wasted motion does not only apply to the production line; moving equipment, unnecessary reaching, looking for parts and tools, confusing standards, walking to and from maintenance, poor visual management, floor layout, and improper work content order are all wasted motions.

There are rare occasions when extra motion is required, and it is still considered wasteful even though it may be necessary. Material handlers are typically responsible for delivering parts to the operators to build product. Most companies employ material handlers unless all parts are delivered directly to assembly workstations via a vendor-supplied parts system.

Wasted motion can really hurt productivity. I witnessed one of the worst cases of wasted motion at a company that built vinyl windows. They had a small area established for building the marketing display units used at trade shows and conventions, and to show the selection of products to potential customers. Fortunately, the models were made to order, so there was no wasted inventory or overproduction. However, wasted motion was the name of the game. Once the operator had assembled the wooden stand, she walked approximately 500 feet to retrieve the appropriate window for the display. Along the way, she was frequently stopped by other employees and delayed in conversations. Upon reaching her destination, she would have to sift through dozens of windows piled in a cart until she located the right one for her display. She would then lift this 65-lb window off the cart and place it in an empty cart waiting in queue and begin her walk back to her original work area, again stopping for casual conversation. She walked approximately 1000 feet per round trip, and performed this activity an average of 20 to 30 times daily, which equated to approximately 4 to 6 miles per day of travel time, not including the additional time spent in searching for windows and unnecessary conversation. Just think of the number of displays

she could produce if her area was more appropriately located near the window assembly line.

Defects/Rejects

Defects are often hidden in stacks of WIP generated by overproduction. Product defects are caused by a lack of 5S, poor line flow and layout, overproduction, insufficient training, inaccurate standards and instructions, and the inability to hold people accountable for continuous mistakes. Poorly manufactured products can cause undue harm to the production environment, as well as potentially damage customer relationships.

Rejects can cause line stoppages, requiring operators to rework product that should have been manufactured correctly the first time. An effective kaizen event can eliminate or reduce costly rework on an assembly line; however, practicing a mentality of "build it right the first time" can only be developed over time. Rejects and defects should be identified as early as possible in the process to prevent more faulty parts from being installed. If defective partial product keeps flowing through the line, it is possible that the entire final product may need to be discarded. The best approach to early detection is by implementing a system called quality at the source, which will be discussed in later chapters of this book.

The Eighth Waste

The eighth waste is wasted human potential or wasted skill sets. I became aware of the eighth waste about five years ago, and believe that knowledge of this waste is one reason that Japanese companies have done remarkably better than their American counterparts: they believe in employee empowerment.

One major flaw in today's management is the inability to identify individual employee skill sets and then properly utilize those skills to effectively balance their workloads. Once a company has set up an assembly line successfully, they need highly skilled, dependable change agents to run it. Operators need to be properly trained in kaizen, which will help make their skills apparent. Once that occurs, placement on the line should take skills into account. Ensuring that an assembly line runs smoothly requires that operators be placed in positions appropriate for their abilities. However, an effective line will also incorporate any operator weaknesses in order to provide opportunities for operator flexibility and full coverage on all areas of the floor. Not utilizing individual employee potential or placing employees in positions where they feel uncomfortable and are likely to make errors are wasteful decisions, both of which impact quality and productivity, creating waste issues that will lead to additional waste: the domino effect.

Remember, anything that does not add value to your operations is waste. Waste generates waste and therefore your kaizen program should focus on eliminating it. Once an employee understands the concept of waste, they can easily identify it and develop ideas to rid it from the workplace.

5S

The next step in the training of your employees is teaching them the importance of a clean and organized work environment. This concept of housekeeping is called 5S. When I teach people about 5S, I explain it from the customers' perspective. You need to ensure that customers visiting your manufacturing facility with interest in purchasing products get a good first impression. Typically, the approach is to sit in a room with potential customers, talking about product selection and service. Customers are then taken to a show room in order to see the actual products they may purchase. The irony in all this is that customers do not care about showrooms; they want to see where the product is made. If your production floor is dirty, unorganized, cluttered, and visually unappealing, it shows the customer you do not care about your company. Therefore, the factory floor should look as clean and presentable as a showroom. Some people disagree with the concept of 5S, claiming that manufacturing is dirty and messy by nature. Wrong. In fact, 5S is one of the most fundamental aspects of kaizen and is critical to its success. Without 5S, you have nothing.

The Five Ss:

1. Sort
2. Straighten
3. Scrub/Shine
4. Standardize
5. Sustain

Sort

Sorting is the act of removing and discarding all unnecessary items from the work area. You would be surprised to learn that only a small number of items are actually necessary to do the work. Everything else should disappear. Typically, items accumulate over time due to waste, and operators and supervisors alike will slowly comfort themselves with a collection of tools, shelves, parts, pens, pencils, paperwork, tables, stools, chairs, etc., creating a buffer for waste. As things pile up, the factory floors expand to become huge storage areas of nonessential items.

In many cases, an outdated product will become obsolete, making it unavailable for sale. Although the finished product may be disposed of, all the parts, work instructions, and tools may stay in the workstation. If these items are not removed, operators may accidentally install wrong parts, use outdated instructions, or waste time standing around looking through a heap of unwanted supplies. The necessary parts and tools required for the job become hidden and operators start conducting nonvalue-added activities. After successfully sorting out and eliminating all unnecessary items, your assembly line could shrink by 30%. Get rid of the stuff.

Straighten

Now that the clutter has been discarded, the remaining tables, tools, parts, paperwork, and workbenches should be organized. A good rule of thumb to use when straightening is to keep everything in right angles (see Figure 3.1).

This is a simple example, but it can be just that easy. After sorting through the junk and organizing what is left at the workstation, you may only need a workbench, a pallet of large parts, and a parts rack. There may be occasions when right angles are not the best for a specific material presentation, or perhaps if a curve is required in the assembly line. However, as a rule, straight is generally preferable.

All items remaining in the workstation need to have a place, which should be properly identified, with the required quantity present. Teach your people that everything has a home. Items that sit on the floor should be properly marked with colored tape. Select a handful of colors, and decide which colors will be used for which items as a standard practice. For instance, yellow tape for all material racks and pallets, and blue tape for workbenches or areas where the product sits. Nothing should be on the floor unless it has been identified, placed appropriately, and labeled accordingly (see Figure 3.2 and Figure 3.3).

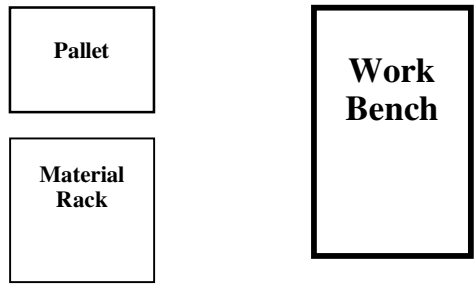


FIGURE 3.1
Right-angle placement.

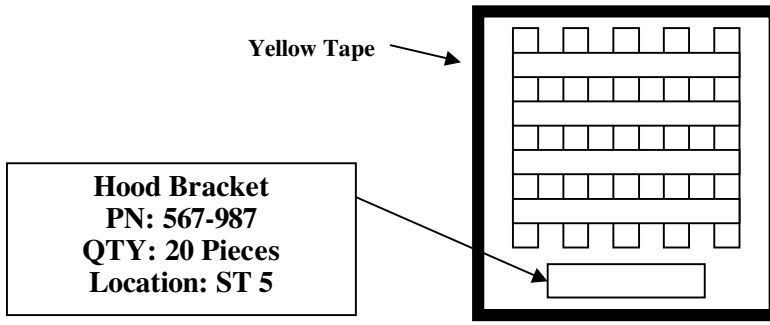


FIGURE 3.2
Top-view labeling and identification.

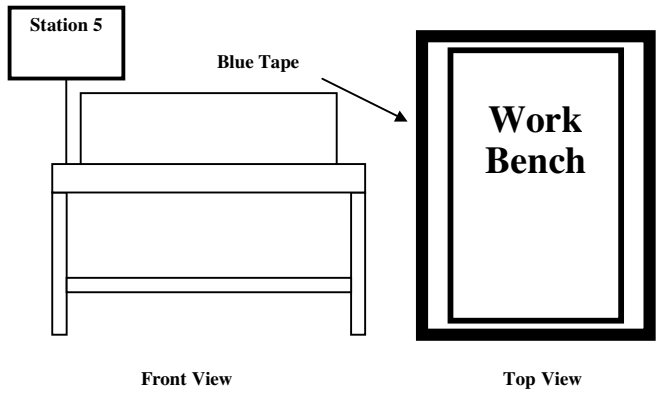


FIGURE 3.3
Workbench labeling and identification.

The material rack should be marked with yellow tape and labeled. The parts remaining in the workstation will now have a designated place in the material rack as well (see Figure 3.4, Figure 3.5, and Figure 3.6).

Simply defined, straightening is the process of organizing anything left over from sorting, and includes identifying locations and names, and establishing quantities. There is a bit more to straightening and I will go into more detail in the chapters devoted to kaizen events.

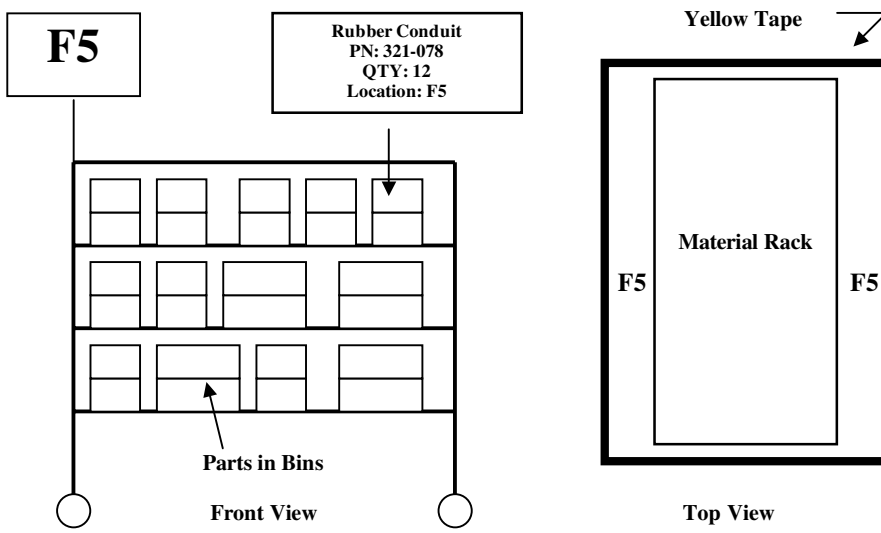


FIGURE 3.4
Floor and material rack labeling and identification.

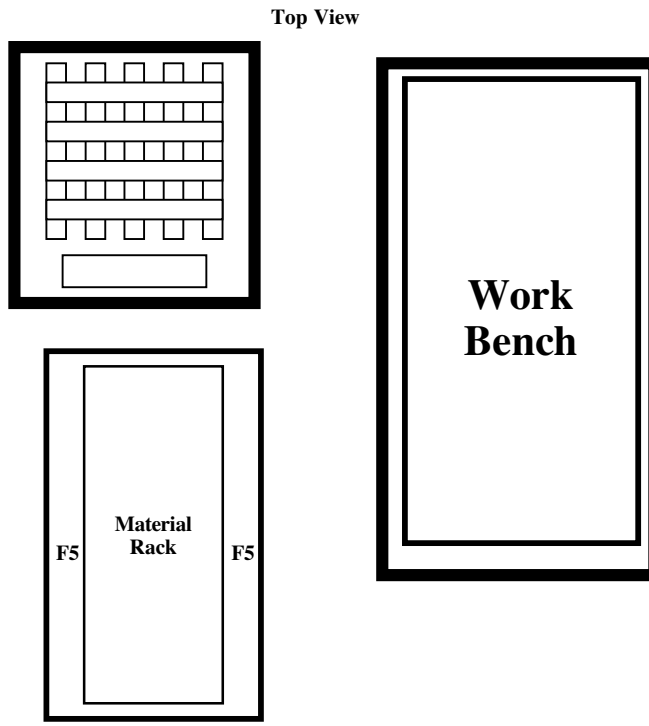


FIGURE 3.5
Top view of workstation.

Scrub/Shine

The third S is quite self-explanatory. Everything in the work area should be cleaned to help give it a showroom appearance. Keeping the workplace clean and organized will give the operators a sense of pride, and you will find that they will want to keep things that way. Scrubbing is not only good for appearance, but it helps to prevent accidents and possible injuries. Wet, dirty floors are a safety hazard for all employees walking though the work area; therefore, they should be kept clean and free of debris. Tools should be kept clean and maintained regularly to ensure proper use and longevity. Dirty workbenches and material storage areas could cause visual defects on parts and product. Foreign material could get lodged into complex circuits or wiring and cause product failures. Equipment should be routinely cleaned and maintained, and wires and cables kept free of dust, dirt, and grease to increase reliability and decrease the possibility of fire or breakdown.

A clean floor allows better tape adhesion so that part and equipment designations stay permanently marked and easily identifiable. Dirt and dust should be cleaned from floor labels so that part numbers and quantities are readable. Every workstation should have a broom, dustpan, and other cleaning material, and workers should be required to clean their area properly at

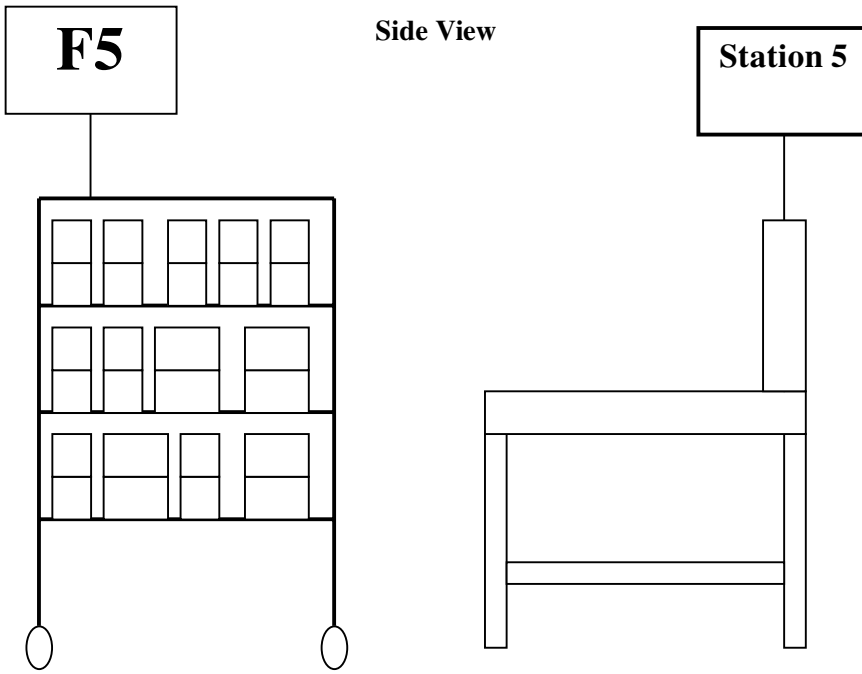


FIGURE 3.6
Side view of workstation.

the end of a shift. If the floor is painted, which I highly recommend for appearance, it should be cleaned regularly to maintain its showroom look.

Standardize

To ensure compliance to the 5S program, written standards should be developed to monitor its progress. As mentioned previously, straighten and maintain consistency with colors and identifications.

Cleaning and organization requirements should be posted clearly at each station. Provide time at the end of each day to clean and to place items back into their designated locations. Operators should be allowed to straighten as needed, placing parts, bins, and tools in order to make their work more efficient. Make 5S a way of life and keep everything as standard as possible.

Sustain

To ensure compliance, have your kaizen champion create a 5S audit that will be used weekly. Remember, change is never easy, and sustaining the 5S program is the most difficult challenge. Humans are naturally resistant to change, so many companies complete the first four Ss only to have a mess again in a few short weeks. However, with consistent accountability and

confidence in the program, 5S will increase employee morale, create great first impressions for customers, and keep your operation running smoothly.

Develop a tracking system for the 5S program along with the weekly audit. A little competition is healthy between assembly lines and work areas. Offer fun incentives for the highest scores, like free lunch or assigned parking places. Be creative in your approach and your employees will be stimulated to participate positively.

Standard Work

Whenever I hear management discussing the implementation of standard work, I immediately get mixed feelings. I believe that standard work is the best approach to manufacturing because it can catapult a company towards world-class status. It's a fantastic concept and I support it 100 percent. Even so, my second response is always to question, "Are they ready for standard work?" Your culture will have more resistance to the implementation of standard work than any other kaizen philosophy. However, with effective training, dedicated persistence towards achieving results, and proper implementation, standard work is the answer to much of the confusion that exists on the production floor.

Standard work is the best, most efficient, safest, and most practical way of doing work. It is the process of documenting and standardizing all tasks, so that authorized, standard procedures are used at all times, on all shifts, and by all operators. The best and most reliable methods should be agreed upon for each process in the facility, and then documented standard work leaves nothing to chance or personal preference. It is a highly organized method of ensuring that proper work procedures are used, and, if deviations ever occur, it allows for easy identification as well as resolution. Operators will know precisely what to do, when to do it, and how long to do it. Standard work simply reduces variability within your processes. It is improvement driven.

Many assembly lines already have some level of standard work in the context of work instructions and directions on how to operate equipment. However, standard work goes well beyond instructions: it is a way of doing business. Your kaizen teams will be actively involved in developing standard work, as well as improving existing standards.

Examples of standard work are:

- Work content in a workstation
- Work instructions for that work content
- Required quality responsibilities in a workstation
- Safety requirements and procedure for operating equipment
- Forklift driver routes
- Material handler assignments
- Operator manuals for machinery

Another benefit to standard work is that it is measurable. Managers can easily evaluate operators and operations because standard work is a simplified approach to working. Without standards, there is no basis for evaluation.

There is always room for improvement to standard work. Once standard work is implemented, the process can be revised over and over again to make it even more efficient. Regardless of other activities, your company should always be in a mode of continuous improvement. Operators working under new standard work should use their day-to-day kaizen responsibilities to find ways to improve the methods, and have the authority to make improvements since a kaizen event may not be scheduled for a few months.

When standard work is in place, giving direction and training to operators and supervisors is a simple process. Once that occurs, everyone on the factory floor will be able to recognize when processes become out of control.

Your kaizen champion should develop an audit system, similar to the 5S audit, to track and monitor standard work. The standard work audit should be done on a weekly basis, just as the 5S audit should be done.

Standard work is the way to go, and getting there will take some work. Your kaizen teams will be heavily involved in the implementation of standard work, which is the best way to fully understand how it works because implementation provides the opportunity to learn from mistakes.

Chapter Summary

- Before kaizen events can take place, employees need to have a general understanding of the seven wastes, 5S, and standard work.
- There are two work activities in manufacturing: value-added work and nonvalue-added work.
- Seven wastes: overproduction, wait time, transportation, overprocessing, inventory, motion, and defects.
- Removal of waste should be the main concern of all kaizen teams.
- The term 5S is a housekeeping philosophy about maintaining order and cleanliness in the work area. The five Ss are: sort, straighten, scrub/shine, standardize, and sustain.
- Standard work is an agreed upon set of work methods that is the best, most efficient, safest, and most practical way of working. These work methods establish the most reliable manner for each process and worker.
- Standard work leaves nothing to chance by eliminating the variability within the process so operators can produce a quality product in the same manner over and over again.
- Standard work is measurable.

4

The Strategic Purpose

A company kaizen program is put in place to serve as a business strategy for making and sustaining improvements. Before any assembly line kaizen events are conducted, your company must do some initial groundwork, which will be covered in this chapter.

Cutting lead times and managing costs are the main factors of lean manufacturing. Lead times can be reduced by eliminating waste and implementing 5S and standard work. Most managers try to cut cost, rather than manage it. But firing employees, downsizing, improvising, and abusing suppliers will not take a company into the future. An effective manager oversees the processes of producing and selling products while maintaining a low level of expenditures.

There are many costs associated with poor assembly line design, such as poor quality and productivity, excessive inventory, long assembly lines, machine downtime, poor use of floor space, and long lead times.

Reducing lead times and wait times for your customers is important in order to stay competitive in the world economy. Customers have certain expectations on delivery, quality, and cost. Manufacturing processes have to be designed to accommodate these expectations. In order for this to occur, there must be a fundamental understanding of time, product families, and how refinement of key processes can be improved.

In Chapter two, I discussed the kaizen event tracking worksheet and its important categories. One category was the strategic purpose. Kaizen events should be scheduled initially in areas in need of waste reduction, 5S, standard work, and visual management, because any improvements would yield quantifiable results and help the overall business. In this chapter, I will discuss the following items:

- Business metrics
- Effective hours
- Product volume
- Takt time and cycle time
- Visual management

Business Metrics

Productivity

Productivity is improved when more products are manufactured with less effort. This means that the less material, manpower, utilities, and equipment used to produce product, the more cost reduction can occur.

However, there is a common misconception about productivity: If an organization reduces the amount of resources needed to make a product, and the employees work at a rate that is not sustainable, productivity will decrease. This reasoning is in error because the focus should be working smarter and more efficiently with less resources, not working faster.

Having more operators on the line than needed is not cost effective, nor prudent, as more hands on the product increases the probability for error. One of your goals should be to reduce the number of operators on the assembly lines. However, I must caution you: this is not about people losing their jobs. Kaizen is about job creation, not job loss. Once an employee's service is no longer required on the line, they should be redeployed to other areas of the plant. This process has a positive domino effect; as you become more productive, with more opportunities for new customers, higher volumes, and new products, jobs will become available, and again, you can redeploy skilled employees to the new assignments.

Floor Space Reduction

Manufacturing companies use more floor space than they truly need. After an aggressive 5S campaign, floor space can be significantly reduced. Again, less is always better. By utilizing space efficiently, and not accumulating unnecessary items, more assembly lines can be constructed to accommodate new products or additional volume. Machines, equipment, and material should be placed as close to the point of use as possible, reducing the amount of wasted movement. One company I worked for assigned a cost to floor space, calculated by the square foot. After a kaizen team had successfully reduced floor space by 1000 ft^2, the kaizen governing committee recorded a savings based on leasing the space at a cost per square foot. It is common for a kaizen team to focus on floor space reduction as their first priority.

Work Station Reduction

Station reduction goes hand and hand with productivity and space reduction. Fewer stations mean fewer workbenches, tools, parts, space, inventory, WIP, material, and storage. Utilizing the appropriate number of workstations limits the amount of operators and therefore decreases the opportunity for error. If a kaizen team is assigned to increase output on a line due to greater

market demand, stations may need to be added to the line. I have led events in which we added stations; however, before doing so, we determined the correct ratio of stations to volume, so that productivity was still improved.

Travel Distance Reduction

Long assembly lines generate plenty of waste. Longer production lines require more operators, more lead times, and more WIP. It is important not to confuse travel distance or throughput with total product cycle time. Total product cycle time is the longest path from fabrication or supplier to the final product, whereas travel distance is the distance the main product has to travel to get to the end of the assembly line. The longer a product is in production, the more it costs your organization. Two years ago, I led a kaizen event at a plant in South Carolina in which the travel distance of an assembly line was reduced from 250 ft to 20 ft. During the first day of the kaizen event, the team removed over 25 workbenches, dozens of tools, obsolete paperwork and parts, chairs, shelves, and other unnecessary items. By eliminating 230 ft of travel distance, product time on the line was shortened from two days to just 1 h 45 min. Theoretically, this improvement would allow a product to be ordered at 8:00 a.m. and be on the truck for delivery by 10:00 a.m. Since some companies allow local customers to pick up products themselves, shortening your assembly line can truly allow for the capability of product on demand.

Quality

I believe that the best way to describe this metric is to discuss quality at the source in more detail. As you may be aware, quality is not inspected or audited into a product, and although inspections are necessary, they should not be relied on as a means to improve quality. Quality is built into the product. Quality at the source is a philosophy that places the responsibility of quality at the point of manufacture, the workstation.

Operators need to be trained on the critical quality criteria expected from them in their workstation. After work content is established, operators should be required to check for any critical build errors that occurred in the previous station before beginning their own portion of the build. Once they have completed their activity, they should check the product again before passing it on to the next station. As this process is repeated again and again, errors are caught much faster, and the operator builds quality into the product.

It is important that operators learn to perform these checks effectively, but that it doesn't change the focus of their job to one of an online inspector. Simply train them to check their work accurately, and encourage them to take pride in how they build. Quality at the source will go a long way towards improving quality and empowering your people.

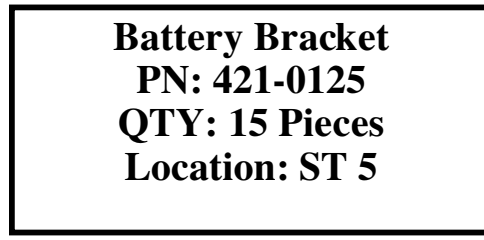


FIGURE 4.1
Bin label.

Work in Process (WIP) and Inventory Reduction

There are essentially two types of material: raw material and finished product. Of course, there are also a few different levels in each type. Sheets of steel can be cut into smaller parts, which are then fabricated into little brackets. These brackets could go onto a wire harness subassembly, for instance, that can then be installed into an ATM machine. In any and all cases, reducing work in process and inventory will lower costs tremendously.

Inventory on the assembly line should be kept at a minimum. After identifying the parts necessary for specific workstations, proper quantities should be set. Every company has different volumes with multiple part configurations. Part quantities should be established based on your organization's needs. During the past few years, I have used two part quantity distinctions: common and uncommon. Common parts were defined as parts used to build more than one type of model; these were placed on a 4-h replenishment time cycle. Uncommon or specialized parts were placed on an 8-h replenishment time cycle. (Of course, shorter time cycles are always preferable, and I typically reduced the replenishment time after the kaizen event had taken place.) The 4-h lead time represented a specific part quantity, usually half the volume. Therefore, if the volume on the line is 50 units and each unit uses one of those parts, the bin would hold 25 parts. To ensure the correct quantity, all bins should be labeled accordingly (see Figure 4.1).

Part description
Part number
Part quantity
Location on the assembly line

This will reduce the amount of inventory in the assembly line and keep the area organized. Many companies think that it is good to hold large quantities of parts on the assembly line to reduce the amount of indirect labor needed to supply material. It is also believed that more parts on the line means fewer chances for delays due to part shortages. This is wasteful

thinking. The assembly line is not a warehouse and the fewer parts in the workstation, the better.

Inventory is also impacted by finished subassemblies waiting to be installed in the final product. Overproduction occurs because the same fears exist regarding machine failures, employee absences, and so forth, triggering a response to build more in anticipation of future problems. Yet, if these are built beyond what is required, additional raw materials are used, and false signals are sent to inventory. Establishing appropriate signals and quantities will prevent this from occurring.

Effective Hours

I grew up in Bellingham, Washington, and attended college at Western Washington University. In May 2004, I took a trip back to Washington to visit with family and my college friend, John. John was working as a manufacturing engineer for a small manufacturer of automotive products. The company was in the middle of expansion and was adding to their existing building to accommodate an increase in business. My first day in Washington, John invited me to see the facility. The tour was quite interesting, and although there was room for improvement, it seemed to be a smooth-running operation. John showed me the company's production control board that was used to visually display daily progress. Each department's output was written on the board, indicating the number of units produced. Yet, one flaw was obvious: Everything was based on eight hours of work, which is not typically the amount of hours spent working, a mistake made by many companies when tracking progress.

Effective hours are the true amount of time associated with operators touching and building product. There are many factors involved in establishing effective hours, and every organization calculates it differently. When calculating effective hours, you need to consider the following:

The time operators are in the building
Lunch (paid or not)
Coffee breaks
Morning meetings
Clean up and 5S
Kaizen

Forgetting the importance of effective hours can be an early stumbling block. Actually, in a manufacturing environment, when dealing with time of any kind you must try to be as accurate as possible. Figure 4.2 shows the calculation of effective hours.

This format has worked very well for me. Of course, there will be some differences from one company to the next, depending on paid or unpaid

510 Minutes	Total Time in the Facility
-30 Minutes	Lunch (Not Paid)
-20 Minutes	Two Coffee Breaks
-15 Minutes	Morning Meeting
-15 Minutes	End of Day Clean up and 5S
-20 Minutes	Day-to-Day Kaizen Activity
410 Minutes	Effective Hours

FIGURE 4.2
Calculation of effective hours.

lunches, as well as how coffee breaks are used. However, every day should include time for a morning kickoff meeting, end of day clean up and participation in 5S, and time for the operators to conduct kaizen.

In my example, the operators will be building products for 410 min or 6 h 50 min, and this time is considered effective hours. Use of effective hours is a common practice, even in companies that do not practice lean or kaizen. Once your organization has established the effective hours for running the shop floor, create a permanent document outlining the hours, and post it on the kaizen event board.

Product Volume

The next piece of the puzzle is to estimate customer demand and determine the production requirements of the assembly line. A forecast is either lucky or lousy, but whether an organization builds to order or builds to stock, the amount of daily product volume has to be determined. Naturally, each company will do this differently, but I am providing my ideal as a reference.

First, take a look at the number of products on your assembly line. Do you operate a mixed model product line (multiple products manufactured on the same line)? Typically, the products on a mixed model line have a certain level of commonality, allowing them to run down the same assembly process. Or do you run a single model line?

After identifying the products, the second step is to determine the daily output. Review the production numbers from the last three years to identify any trends in product demand. Then, retrieve next year's sales forecasts from your sales and marketing department to be aware of their projections.

Next, you must determine the number of days that the production floor will be operating during that year, excluding weekends, holidays, company picnics, Christmas parties, and planned shutdowns. Every company works a different number of days during the year. Be sure that all designated

company non-work days are identified and excluded so that an accurate product volume can be established (see Figure 4.3).

Figure 4.4 shows the model mix of assembly line if the 2006 total planned volume for assembly line A is 8399 units.

Assembly line A should be set up to build a total of 37 units a day broken down by the individual product requirements shown to meet customer demand (see Figure 4.4).

Figure 4.5 shows the single model mix if the 2006 total planned volume for assembly line B is 2560 units. The calculation is quite simple since it is a single model product line.

Assembly line B should be set up to build a total of 11 units a day of product 210A to meet customer demand.

365 Days in the Year
-115 Weekend Days
-13 Holidays
-5 Summer Shutdown Days
-5 Winter Shutdown Days
227 Days Available to Work

FIGURE 4.3
Calculation of working days.

Product	% of Volume	Units	Divide by 227
100A	30%	2497	11
110A	25%	2043	9
110B	18%	1589	7
111	27%	2270	10
Total	100%	8399	37

FIGURE 4.4
Assembly line A (mixed model line).

Product	% of Volume	Units	Divide by 227
210A	100%	2560	11
Total	100%	2560	11

FIGURE 4.5
Assembly line B (single model line).

Takt Time and Cycle Time

Takt Time

Takt is the German word for "rhythm," or "pulse." Takt time is a well-known manufacturing term; however, it is defined differently from one company to the next. Based on the product volume of the assembly line, all processes that are directly or indirectly related to the line should follow the same takt time. Takt time is essentially the time to complete a unit in order to meet the designed output of a given process. The takt time formula is shown in Figure 4.6.

Using the previous examples for effective hours and product volume, takt time for assembly line A would be calculated as shown in Figure 4.7.

Based on this calculation, assembly line A should be designed and constructed so that a task is completed at every workstation every 11.08 min. One complete unit should come off the assembly line every 11.08 min to ensure that 37 units are built every day. If assembly line A begins operating on two shifts a day, the number 1 in the formula should be changed to 2, doubling takt time to 22.16 min. It is a much higher takt time; however, with both shifts working, assembly line A would still produce 37 total units by the end of the day.

Remember, effective hours, number of working days, product volume, and the number of shifts can all be adjusted as needed. You may wish to work four 10-h days, allowing the operators to have three days off each week. Or, if your organization operates under a 35-h workweek, effective hours would decrease. The numbers can be adjusted to reflect your organization, and readjusted whenever necessary.

Cycle Time

There is often confusion between takt time and cycle time. Although these terms may appear similar, they are actually quite different. The assembly line takt time will not change unless product volume and effective hours change. In contrast, cycle times may vary from one station to the next.

$$\text{Takt Time (T)} = \frac{\text{Effective Hours x \# of Shifts (t)}}{\text{Product Volume}}$$

FIGURE 4.6
Takt time formula.

$$\text{Takt Time} = \frac{\text{410 Minutes x 1 Shift}}{\text{37 Units/Day}}$$

$$\text{Takt Time} = \frac{410(1)}{37}$$

$$\text{Takt Time} = 11.08 \text{ Minutes}$$

FIGURE 4.7
Assembly line A takt time.

Using the 85% rule is critical when designing an assembly line. Many manufacturers today seem to be in a constant state of panic (like Company Z in the Introduction of the book). A contributing factor to this mass hysteria is a basic misunderstanding of the 85% rule, or, the level of work placed on a human being in any manufacturing process. Operators cannot work at optimum rate or speed, 100% of their shift, or they will become less productive, create more defects, become injured, and miss more days on the job. A realistic operator load of 85% allows for a smooth and efficient flow of product, without jeopardizing quality, productivity, or health. The 85% loading is not slow; it simply allows operators to work at a productive rate, which results in properly built, quality products.

Referring back to my example of assembly line A, takt time was 11.08 min. To determine the 85% load, multiply 11.08 by 0.85.

$$11.08 \times 0.85 = 9.41 \text{ min}$$

Takt Time = 11.08 min

Cycle Time = 9.41 min

Basically, the takt time of assembly line A is still 11.08 min; however, to comply with the 85% rule, work at the station should not total more than 9.41 min. Although the operator has 11.08 min to complete their task, they are only loaded to 9.41 min.

Of course, not every workstation will be set to exactly 9.41 min, but an attempt should be made to balance the work content within the stations as closely as possible. See Figure 4.8.

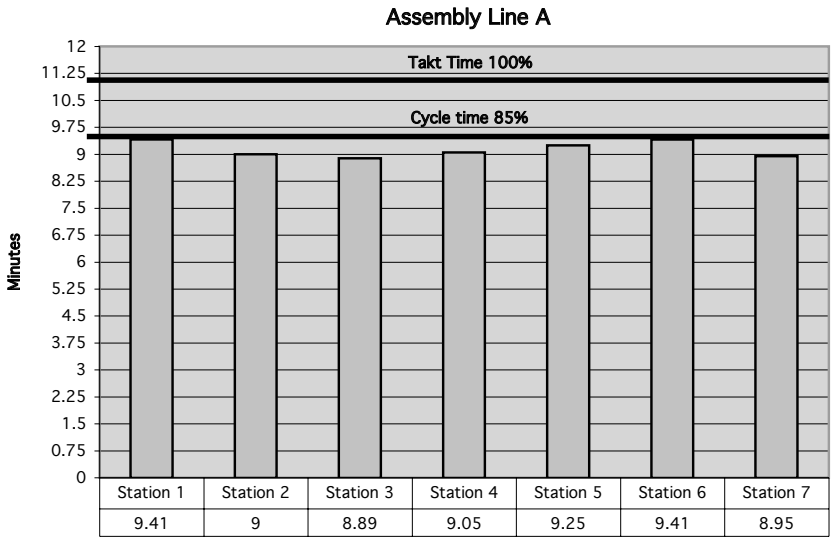


FIGURE 4.8
Assembly line A workstation loading.

Visual Management

Abnormalities and problems happen daily on the production floor. No matter how refined the processes are, issues will arise and will need resolution. Early identification of these problems is key to keeping the assembly line running smoothly and, one would hope, avoiding impact to daily output volume. Implementing visual management to track and monitor your company's business metrics is essential. Visual management depends on the fact that production process information is clearly visible to all employees, so that quick identification and response is possible. Items such as safety, productivity, production status, 5S, and quality should be visually available to all employees at all times.

There are a variety of ways to display information about the plant's operations. Regardless of the method chosen, it is also recommended to post critical information specific to an assembly line or area. The following is a list of common approaches to visual management:

Production control boards
Weekly 5S board
Daily quality board
Safety board
Daily productivity board
Takt monitors

Production Control Boards

Production control boards are used to track production status, and are best placed at the end of the assembly line. You should be monitoring the progress of the assembly line for every takt time. When the line does not move on a given takt, the problem should be identified and resolved as quickly as possible. The production control board can be a dry-erase board or chalkboard, and should be divided into columns to indicate the following:

Unit – This first column represents which unit the last workstation should be working on.

Clock time based on takt time – The next column should indicate the clock time when a unit should have been produced. In some cases, when takt time is very short, units should be tracked by the hour. For example, if a takt time is 60 sec, it will be difficult to maintain, therefore, production status should be tracked by the hour.

Target Units – A unit should be finished every takt time. This column indicates how many units were built during that takt time. For example, if 1/1 is indicated, that could represent one unit built, and one required, per takt.

Total – This column indicates the total number of units at any given time. For example, an entry of 1/3 indicates that the assembly line should complete

Line A

Takt Time: 11.08

Daily Output : 37

Unit	Time	Target	Total	Reason
1	8:26 AM	1/1	1/1	N/A
2	8:37 AM	1/1	2/2	N/A
3	8:49 AM	0/1	2/3	Air Tool Broke
4	9:00 AM	1/1	3/4	N/A
5	9:11 AM	1/1	4/5	N/A
6	9:22 AM	2/1	6/6	N/A
7	9:33 AM	0/1	6/7	Test Failure
8				
9				
10				
11				
12				
13				
37	4:00 PM	1/1	37/37	N/A

FIGURE 4.9
Production control board.

three units, but has only produced one. After an ideal production day, both the numerator and denominator should be the same.

Reason – This column is used to indicate the reason that a line fails to meet its required unit per takt, and should be updated by the production supervisor managing the line. This allows for faster response from the responsible person or department. For example, if a tool malfunctioned, maintenance and the manufacturing engineer can respond and repair the tool quickly to avoid further delays. Figure 4.9 provides an example of a typical production board used to track status.

The information contained in the Reason column can be discussed at the next production meeting, even if issues are resolved. Using a production control board to focus meeting discussions can control conversation and shorten meeting lengths, as well.

Weekly 5S Board

Every Friday, the kaizen champion should conduct a brief audit of the assembly line and other processes in the plant. The following Monday, these results should be posted to show other areas in the plant how well they have complied with the 5S criteria. The best way to record 5S is by using three different colors to chart information, as follows:

Red	Area does not meet 5S requirements
Yellow	Area meets minimal 5S requirements
Green	Area meets 5S requirements

The production floor should be divided into different 5S teams, using their process as a method of separation (my recommendation). For example, six assembly lines would represent six separate 5S teams. A fabrication department can be one 5S team, as can receiving, shipping, the stock room, paint room, and so forth.

Employees will be assigned to a 5S team and be responsible for keeping their areas clean, safe, and organized. Every week the results will be made public to the whole company. Everyone will see who is complying with 5S and who is not. This will create a healthy level of competition between 5S teams and help motivate the teams to do better. The 5S board is not intended to "point the finger" at areas that are not performing, but rather, to help generate awareness of areas that need attention.

Daily Quality Data

Quality is tracked differently from one organization to the next. Some focus on parts per million (PPM), others simply look at the number of rejected units or defects per internal audit. Regardless of how quality is tracked, the information should be posted for all the employees to see. This data should be made visible, not to assign blame, but to indicate the lines or areas needing improvement or a kaizen event. Quality data from the previous day should be posted before the morning meeting to allow the quality department to review all the issues.

Safety Board

Safety should be the most important initiatives in the company. Even if productivity is 100%, there are 0% rejections, and the entire plant is 5S

compliant, you will definitely have big problems if operators are getting hurt and missing work. Just like quality, safety can be tracked in various ways.

The most common metric within safety is recordable lost time due to injury. Based on that definition, not all injuries should be tracked. To clarify this point, an operator who cuts himself on a piece of thin sheet metal and requires a band aid should not be included in lost time due to injury. However, if an injured operator requires care from a hospital or medical facility, this should be counted as lost time. Some manufacturers define lost time as short-term disability; that is, an injury requiring the employee to miss a day or two of work. I personally consider lost time whenever an employee has to leave work for medical care. In summation, lost time, per line, due to injury per line should be posted, and, of course, a company should always strive to see the lowest number possible on this board.

Daily Productivity Board

Productivity and cost go hand in hand. When an organization posts productivity results, they are essentially posting cost. The production control board is used to track productivity every takt; however, end of day productivity should also be displayed for the morning meeting the following day Assembly lines are designed to achieve specific productivity, and the results for each day should be compared against the expectations. Daily decreases in productivity produce cost increases. Therefore, employees should be made aware of the importance of productivity and become more efficient in their day-to-day operations.

Takt Monitors

Even when operators are working to achieve takt time, they may not be aware of their pace as it relates to the required takt time. They need to know if they are working too slow or too fast, and takt monitors will serve this purpose. Takt monitors can be installed at the beginning and end of each assembly line. Although the monitor at the end is the most useful, it is good to have one at the beginning as well. The front-end monitor alerts the operator in station one of a stalled line because of a bottleneck upstream. Figure 4.10 shows an example of a typical takt monitor.

As you can see, the information on the takt monitor is very simple and explains the current conditions of the assembly operation. Takt monitors are electronic and come in a variety of sizes and styles. Most takt monitor systems are accompanied by networked software, allowing managers to monitor the line's progress from any computer. If you are using such a monitoring system, it is good practice to do scheduled maintenance to ensure that the takt monitors are performing correctly and providing accurate information.

Training is critical to the success of your kaizen program. Understanding the fundamentals of waste, 5S, standard work, visual management, and the basic calculations necessary for planning and tracking is important for each

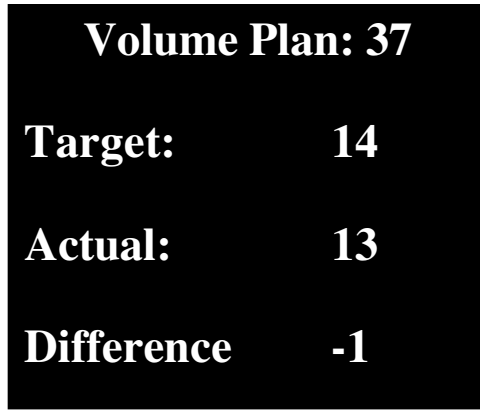


FIGURE 4.10
Takt monitor.

employee, before they attend kaizen events. Once the employees are trained, participation in kaizen events will help the kaizen teams and employees understand why certain projects are taking place. Operators will be the first to rebel against the change because they are typically the first employees to be affected by it. Their workstations and assembly lines will be drastically altered, and it will be difficult for them to break old, established working habits. However, the transition will be much easier when they are properly trained and have been selected as a member of a kaizen team. Over time, your organization will come to accept kaizen as a way of doing business and not some "fly by night" idea that will quickly disappear. Unfortunately, there will be some attrition. Your organization will have certain individuals who continue to resist until, eventually, they leave the company voluntarily or by being terminated. To keep these employees at a minimum, it is important for the kaizen governing committee to understand all the fundamentals described in this chapter and be able to disseminate the information to all employees through training. The kaizen governing committee and the kaizen champion are responsible to lead by example, demonstrating enthusiasm for kaizen and a solid commitment to the kaizen program and all kaizen events. The ability to lead your organization determines the success of your kaizen program. Good luck.

Chapter Summary

- Cutting lead times and managing costs are the essence of lean manufacturing.

- It is important to understand the delivery, quality, and cost expectations of customers.
- Kaizen events should be conducted to help improve the key business metrics.
- Effective hours are the time that operators spend working on product.
- There must always be time for kaizen and 5S activities.
- Takt time is the German word for rhythm. It is the time a unit must be complete to meet the designed output of a given process.
- Always apply the 85% rule to takt time to ensure operators are not worked at a pace that will create safety and quality problems.
- Cycle time is the amount of time needed to do the established work in a workstation or area.
- Visual management involves making information about production processes visible in a clear and concise manner so quick responses can be made.

Electric Bike –
Kaizen Event Preparation

5

Four Weeks to Go

Planning is essential to the success of any kaizen event. Good upfront planning and ordering of material and supplies will allow the team leaders to allocate projects and meet deadlines. With only four weeks left until the event, there are still some items left to address. Figure 5.1 shows the outstanding items.

Select the Area and the Kaizen Team Leader

Remember, kaizen events are scheduled and the team leader is selected four weeks in advance. The kaizen governing committee evaluates all the employee input regarding which areas require a kaizen event. The committee should assess the possible benefits of the event and decide if it will impact the business in a positive way. Once the area is determined and the event is scheduled, they must select the team leader who will drive and the lead the kaizen team to success. It is also good to make a list of potential team members for an event. The kaizen champion can select the team members from this list, and then finalize the list two weeks prior to the event.

Order Supplies and Equipment

The kaizen champion should do a quick assessment of the tools and supplies in the kaizen event supply box to ensure that all necessary items are in place. When a kaizen event begins, it is critical that all materials, equipment, and individuals providing support are available, or the event will fail. Depending on the size of the company, some manufacturers have machine and fabrication shops on site which can be used to help design and build certain items the team may need. Companies with this ability need to order materials now, so that the fabrication and design departments can be utilized when required.

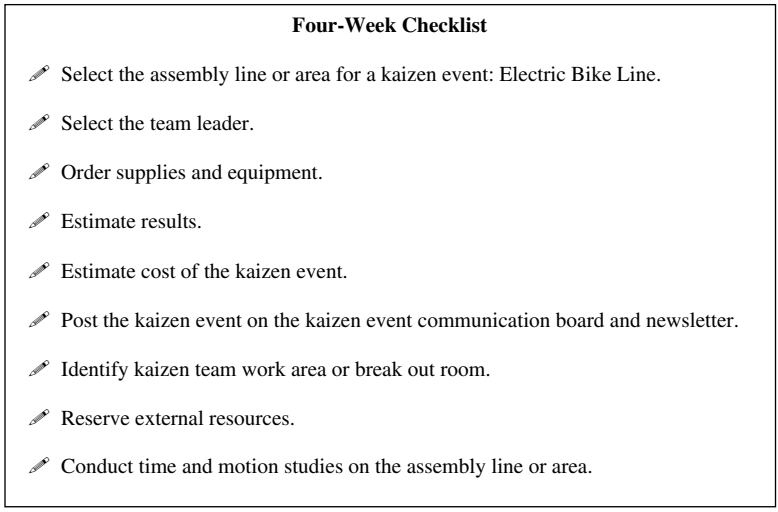


FIGURE 5.1
Four-week checklist.

During this preplanning phase, it is also good practice for the kaizen governing committee to study the target area's current work processes and try to come up with new, more efficient processes for the operators, or any new tools they may need to make their task easier or more productive. It is a great time to ask some good questions. Does the company want to buy all new air tools for the line? Will the line use a conveyor belt or lift tables? Special equipment, tools, fixtures, or other devices may need to be preordered or prebuilt to make the assembly line operate more effectively. Most kaizen events can be conducted without spending a lot of money; however, a kaizen event is also an opportunity to enhance the line with better operating tools or safety equipment, or to fine-tune an existing piece of machinery to make it operate more efficiently.

Listed below are recommendations for designing a new assembly line. Some of the items might already exist in an old assembly line and can simply be incorporated into the new line. However, if they are not available, these items should be considered when designing the new line.

Antifatigue mats
Lift tables
Tool balancers or retractors
Metal tubing
Floor tape
Laminating material, labels, and parts racks
Plastic part bins

Workstation lights
Tower lights

Antifatigue Mats

Management frequently forgets how hard it is to stand on a concrete floor all day. The human body is not designed to stand or walk on concrete, especially for eight hours at a time. Antifatigue mats are available in a variety of designs, and there are plenty of suppliers who sell them. They usually come in roll form or are precut. The roll form is less expensive because the cost of cutting it into pieces is the responsibility of the consumer. Antifatigue mats can significantly reduce stress on the operator and will help promote better productivity.

Lift Tables

Many manufacturers using assembly processes build product on lift tables. Lift tables allow the operator to maneuver around the product by placing the product in the appropriate position. Rotating lift tables can be used as well. The operator can turn the product 360° while moving the lift table up and down. If the old line did not utilize them and the kaizen team wants to implement them, they should be ordered ahead of time.

Tool Balancers or Retractors

Some kind of hanging device should be used to present the tools to the operator. Tool balancers and retractors allow the operators to use tools as needed without having tools cluttering the work area. With these devices, tools can be used and then automatically retracted to the overhead device.

Metal Tubing

It is always good to have a variety of fabrication material on hand, which can be used to build any items the kaizen team wishes to implement. One-inch metal tubing is a very common material used during kaizen events. Tool stands, shelves, fixtures, documentation holders, and carts are usually built from 1-in. tubing, so, it is wise to have some on hand at all times.

Floor Tape and Laminating Material

I mentioned floor tape in Chapter 2 when discussing the kaizen event supply box. This is a good time to assess the supply of floor tape and laminating sheets, and, if necessary, place an order for the kaizen team.

Labels

Labels will be used during the implementation of visual management, so it is good to have a few sizes available for the kaizen event. Most office supply stores stock labels, which you should purchase in a variety of colors.

Parts Racks

Parts racks are usually made from thin stainless steel and are quite easy to handle and assemble. Most parts rack manufacturers offer different styles and options. The kaizen team can use this to build a custom shelf for a workstation that is designed to hold parts, part bins, work instructions, tools, or anything else required to perform the work. I recommend ordering mobile parts racks that come with wheels. The more mobility an assembly line has, the better. If the old line already uses wire parts racks, there is a pretty good chance that, after a 5S campaign, extra shelves will be available. The kaizen champion should do an assessment of the old line and decide if a few extra shelves should be ordered.

Plastic Part Bins

A good way to store material in the workstation is in plastic bins. These bins are very common in today's factories. In a later chapter, I will describe the two-bin material system and how useful plastic bins can be.

Workstation and Tower Lights

An operator needs to be able to see what he is working on, and typically, the lights from the factory ceiling are not enough. If the lighting in workstations is poor, operators may struggle to see intricate parts and cause headaches or fatigue. If possible, install workstation lights during the kaizen event. During the implementation of visual management, tower lights will be installed to allow the operators to communicate to the whole plant.

Miscellaneous Preparation

Now that the event has been scheduled, the kaizen governing committee and the new team leaders will meet to review estimated costs and anticipated results for the event. The kaizen champion will use the kaizen event communication board to post the event, the area selected, and the team leader.

The kaizen champion will provide this information to Human Resources, who will incorporate it into the company newsletter.

It is good practice to use the same work area or conference room for all kaizen events. If there are multiple locations that are suitable, the kaizen governing committee should select one of them and reserve it for the kaizen team.

Depending on the work performed during the event, specialized equipment or contractors may be needed. Contact a local machine shop that can either start fabricating items now, if needed, or can be on call during the event. The kaizen governing committee and the team leader should go over construction issues now, even though it is early in the design phase. External resources should be reserved at this point, so they are available when the kaizen week begins.

Time and Motion Studies

Before any design or construction can take place, the assembly line for the first kaizen event must be selected, and then the work associated with building the product needs to be timed. Collecting time and motion studies are absolute requirements to improving the assembly operations in the facility, and should be done approximately four weeks prior to the kaizen event.

I believe in making decisions based on data. Although, as you will read later in the book, using existing knowledge, developed over time, as well as doing sanity checks, are essential parts of the decision-making process as well. But, using good, solid data never hurts.

Time is everything. Time and motion studies are the foundation of any manufacturing process and have been an early stumbling block for many manufacturers. Upper management generally perceives performing time studies as a wasteful task, so many companies either lack this important information or have inaccurate information acquired incorrectly. I do not agree that time studies are a wasted effort, but believe they should be at the top of your preplanning to-do list.

Traditional kaizen practice is to conduct the time and motion studies on the first day of the kaizen event, and this data is typically collected very quickly. However, to effectively create standard work, and to ensure that the information is accurate, time and motion studies should be done before the event.

Not many individuals can conduct time studies effectively, as it takes time to master the art of data collection. Ideally, the kaizen champion or an industrial engineer should be assigned to the task. To help avoid difficulties, the kaizen champion or engineer should follow some simple rules:

Time and Motion Study Rules

Use a stopwatch.
Use a time study collection sheet.
Document the tasks and elements before timing.
Capture every piece of work content; value-added and nonvalue-added, from start to finish.
Involve the operator.
Conduct the time studies.
Capture at least eight samples of every task or element.
Time all options.
Remove the highest and lowest times and take an average.

Use a Stopwatch

A time studier obviously needs a stopwatch to perform the work. Use a standard digital stopwatch that can be found at any sporting goods store. Try not to purchase the cheapest brand available. You will be using these stopwatches extensively and need one that is reliable and has longevity. Purchase two stopwatches. As your time studier becomes more proficient at the work, two stopwatches will make the task more efficient; two different elements of work can be timed in parallel.

Use a Time Study Collection Sheet

The collection of raw data should be documented and saved for future reference. I have provided a sample time study collection sheet (see Figure 5.2) that can be used to conduct time studies. This sheet was created using Microsoft Excel™, and is very easy to use. It contains all the necessary information needed to document the data, making it easily interpretable for designing an assembly line. The time study collection sheet should contain the following columns of data:

Sequence number
Work content
Value-added work
Nonvalue-added work
Sample quantity
Average

Later in this chapter, I will explain how to complete the worksheet correctly.

Work Description:				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	

FIGURE 5.2
Time study sheet.

Document the Tasks and Elements

Trying to capture too much information at one time is a common mistake when performing time studies. Collecting this data takes time; you should never rush the process. From experience, I have learned to record work content first. Once you are confident that the work content (value-added and nonvalue-added) has been identified, you can then go back and time all the steps, and then return to complete the time information.

Capture Every Piece of Work Content

Documenting work content is not as easy as it may appear. Even one part installation has a lot of work associated with it. For example, "Install Angle Bracket" has a lot of value-added work associated with it, as can be seen in Figure 5.3.

10 Walk and retrieve angle bracket

20 Remove Styrofoam cover

30 Place angle bracket on case

40 Place screws in angle bracket holes

50 Secure angle bracket with tool

FIGURE 5.3
Sample work content.

As you can see, installing the bracket involves many independent tasks, such as walking, retrieving, and so forth. All of this information must be accounted for in order to create a good baseline for future changes. I recommend that the work content be documented throughout the entire process, from the first station until the last station is analyzed. Do not get caught up with stations and number of operators. Create a long, sequential list of the required work to build the product. You can use this list as the foundation from which to implement new changes and new station requirements.

Involve the Operator

During the data collection phase it is important to involve the operators, taking their input about the work performed at their station, as well as any feedback or advice they may have. Allow them to discuss any problems or issues that hinder their ability to perform efficiently, and ask them a lot of questions about their responsibilities. Take a general interest in what they do and let them know that you are collecting data to help them in the future.

This is also a good time to let them know that you will be conducting time studies on the work content. Emphasize the importance of knowing how long it takes to build the product, and explain that it is not an attempt to see how fast they are working. If you present yourself professionally, and take their concerns into account, you will enlist their support for additional studies.

Conduct the Time Studies

After all the work content is documented, and you have spoken with the operators at every station, return to the first workstation and start timing. Be careful not to get in the way and hinder the work that still needs to be done while you are doing the timing. Remember that some individuals may be uncomfortable being timed, and feel that they need to work faster, so assess each situation carefully and use your best judgment. If an operator is clearly nervous, and is stumbling about or working too fast, stop timing that station, go to another one, and come back later. All the work content is documented, so you have flexibility and can time anywhere on the assembly line. Reassure the operators that this is not about speed and that their name and station will not be on the time study collection sheet. This is why I mentioned not to get caught up in operator names and stations. The task is anonymous and the operator will feel more comfortable knowing that. Just make sure the operator has enough experience that the time study provides a true accountability of time.

Capture at Least Eight Samples

Timing work content just once or twice will not yield accurate data for design purposes. All day, the operator is faced with small obstacles and challenges, and this prevents them from having identical work content consistently.

Therefore, it makes good sense to time the same work content at least eight times, ensuring that different situations are accounted for. If an operator drops a tool, looks confused, or walks away to speak with someone, stop timing immediately. Try to distinguish any abnormal activities that would not generally occur, and eliminate those from consideration. This does not mean to skip timing nonvalue-added work like walking and waiting. Capture all the work involved in building product and then separate the useless acts from the useful, typical occurrences.

Time All Options

Many companies offer various options to their customers. Some options are used so frequently they have become virtually standard. However, some options are very rare. It is important to document and time all options regardless of their frequency. This is critical because the new assembly line may experience a high frequency of that rare option, and if not accounted for in the original design, bottlenecks, workstation imbalances, quality issues, and possible shutdowns may occur. Time the product for the worst-case scenario.

Remove the Highest and Lowest Times and Take an Average

After all eight samples have been timed, remove the highest and lowest time, unless they are close to the remaining six samples. The highest and lowest times represent the rare and unusual circumstance, which should not be confused with infrequent options. To clarify, I will provide the following example of an unusual circumstance: An operator is struggling to fit a part into the unit because of a one-time defect from the supplier. Although this may happen from time to time, it should not be included in the design, because it is an unusual circumstance. Take the remaining six samples and average the times. This final time represents the standard time for installing a particular part, and is the best, safest, and most efficient approach to the part's installation.

Time studies are very important, and the accuracy of this data will make or break the new assembly line. After the new line is up and running, errors in the time studies will become apparent very quickly. Do not rush this analysis, but do not take four months to do it either. The time study collection sheet will be the foundation for designing an effective assembly line, so take pride in the collection of the information that will go in it.

Time to Begin the Kaizen Event

The electric bike example used for this book proved to be extremely useful for collecting data that is commonly seen in today's manual assembly operations. The specifications of the bike are shown in Figure 5.4.

Motor Power	500 W
Speed	18 km/h
Maximum Load	100 kg
Recharge Period	7 hours
Range	15 km
Wheel	300 mm
Wheel Material	Rubber
Frame Material	Aluminum
Battery Voltage	110 V
Weight	25 kg

FIGURE 5.4
Parameters of the electric bike.

Time studies were conducted on the assembly of this electric bike, using a stopwatch. Each assembly operation was timed eight times and the high and low values for each were excluded. The high and low values are displayed in bold. The remaining time data were averaged. Subassemblies were established based on the analysis and the remaining data were saved for the main assembly process. The subassemblies that would be assembled in the facility are also in bold text. The ideal situation is to have all assembly work done on one main assembly line. Subassembly work is very common and is not unproductive. Since many manufactures build subassemblies for a main assembly area, I have provided recommendations for designing those processes. The following processes were identified.

Main assembly line
Instruction kit assembly
Mirror assembly
Tool kit assembly
Headlight assembly
Trunk assembly
Main body panel assembly

When collecting this data, it is good practice to document the time in minutes. For example, 15 sec should be written as 0.25 min. This allows you to easily add or subtract data when manipulated with Excel during the waste reduction and line balancing phases. To further explain the design process, I have added common forms of waste that exist in many assembly processes. The data are shown in Figure 5.5 through Figure 5.10.

Work Description: Main Assembly				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Walk and Retrieve Shipping Pallet		X	0.55	**0.52**	0.58	0.55	0.56	0.52	0.61	**0.61**	0.56
20	Install Frame to Shipping Pallet		X	3.24	3.15	3	**2.97**	3.18	3.22	**3.25**	3.2	3.17
30	Walk and Retrieve Front Forks		X	**0.51**	0.59	**0.62**	0.57	0.54	0.61	0.6	0.61	0.59
40	Install (2) Shock Absorbers to Front Forks	X		0.24	0.26	0.22	0.22	**0.2**	0.29	**0.29**	0.28	0.25
50	Install Front Forks to Frame	X		**0.89**	**0.77**	0.79	0.81	0.85	0.83	0.84	0.81	0.82
60	Walk and Retrieve Front Wheel		X	**0.51**	0.59	**0.61**	0.57	0.51	0.61	0.6	0.61	0.58
70	Install Front Wheel to Front Forks	X		0.33	0.34	**0.3**	0.38	0.38	**0.39**	0.35	0.35	0.36
80	Install (4) Black Rubber Bumpers to Frame	X		0.22	0.26	0.22	**0.29**	**0.2**	0.29	0.29	0.28	0.26
90	Walk and Retrieve Battery Pack		X	**0.65**	0.61	0.61	0.57	**0.52**	0.61	0.6	0.61	0.60
100	Install Battery Pack into Center of Frame	X		**0.64**	0.62	0.61	0.57	**0.55**	0.59	0.61	0.57	0.60
110	Install Serial Number Label to Frame	X		**0.18**	**0.13**	0.16	0.16	0.13	0.15	0.15	0.15	0.15
120	Connect Electric Motor to Voltage Tester		X	0.55	0.55	0.56	**0.52**	**0.61**	0.57	0.52	0.58	0.56
130	Test Electric Motor		X	**1.15**	1.22	1.23	1.3	**1.31**	1.28	1.19	1.25	1.25
140	Place Operator I.D. Label on Electric Motor		X	0.19	0.22	0.2	**0.29**	**0.13**	0.15	0.15	0.16	0.18
150	Remove Electric Motor from Voltage Tester		X	**0.49**	0.55	0.55	0.52	**0.63**	0.57	0.55	0.58	0.55
160	Install Electric Motor to Frame	X		**0.62**	0.68	**0.71**	0.63	0.64	0.64	0.66	0.7	0.66
170	Remove Fuse Box From Box		X	0.25	0.25	**0.2**	0.29	**0.29**	0.28	0.22	0.24	0.26
180	Install Fuse Box to Frame	X		**0.48**	0.55	**0.63**	0.52	0.63	0.55	0.55	0.57	0.56
190	Install Horn to Frame	X		**0.31**	0.25	0.26	0.29	0.3	0.28	**0.23**	0.26	0.27
200	Install Drive Chain to Electric Motor	X		**0.18**	0.18	0.16	0.16	**0.14**	0.14	0.15	0.15	0.16
210	Install Rear Wheel Assembly and Wrap Drive Chain around Sprocket	X		0.88	0.95	0.87	**0.85**	0.94	0.92	0.95	**1**	0.92
220	Route Brake Cable from Rear Wheel and Secure	X		1.24	1.19	1.21	**1.26**	1.2	**1.18**	1.18	1.24	1.21

FIGURE 5.5
Main assembly line.

Continued.

Work Description: Main Assembly				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
230	Route Throttle Cable from Rear Wheel and Secure	X		1.21	1.18	1.21	**1.26**	1.2	**1.18**	1.22	1.26	1.21
240	Secure Rear Wheel Assembly	X		1.89	2	1.95	1.92	**2.05**	**1.87**	1.98	1.91	1.94
250	Attach Brake Cable to Brake Drum and Adjust Tension	X		0.71	**0.69**	0.75	0.76	0.74	**0.78**	0.69	0.7	0.73
260	Walk and Retrieve Wire Harness		X	**0.65**	0.61	0.59	0.57	**0.53**	0.61	0.62	0.63	0.61
270	Install and Connect Wire Harness	X		**3.74**	3.65	3.7	3.64	**3.48**	3.49	3.58	3.55	3.60
280	Secure Wire Harness Wires	X		1.3	1.28	**1.2**	1.35	1.27	1.39	**1.4**	1.28	0.56
290	**Walk and Retrieve Main Body Panel S/A**		X	0.54	0.52	**0.49**	0.58	0.57	**0.66**	0.61	0.52	0.56
300	**Install Main Body S/A**	X		**0.95**	1.14	0.99	1.05	1.1	0.97	0.98	**1.18**	1.04
310	Install Black Grommet on Back Suspension	X		0.18	0.16	**0.11**	0.12	**0.19**	0.14	0.15	0.15	0.15
320	Install (2) 1" Lock Nuts Over Black Grommet	X		0.3	0.33	**0.29**	0.35	0.35	0.3	0.33	**0.38**	0.33
330	Install Black Grommet on Front Forks	X		0.11	0.16	**0.11**	0.12	**0.19**	0.19	0.15	0.15	0.15
340	Install (2) 1" Lock Nuts Over Black Grommet	X		0.31	0.32	**0.28**	0.35	0.37	0.3	0.33	**0.38**	0.33
350	Install Seat Post to Main Body Frame	X		0.18	0.16	**0.11**	0.12	**0.19**	0.14	0.15	0.15	0.15
360	Install Seat Cushion to Post	X		0.64	0.68	**0.59**	**0.71**	0.64	0.61	0.6	0.6	0.63
370	Install Seat Quick Release S/A	X		0.22	0.19	**0.19**	0.25	**0.27**	0.21	0.21	0.27	0.23
380	Remove Center Panel from Plastic Bag		X	0.19	0.22	0.2	**0.18**	0.23	0.25	**0.28**	0.23	0.22
390	Install Center Panel Lock To Center Panel	X		**0.25**	0.33	0.21	**0.48**	0.41	0.41	0.28	0.26	0.32
400	Install Center Panel to Main Body Panel	X		0.21	0.19	0.2	**0.18**	0.23	0.26	**0.28**	0.23	0.22
410	Walk and Retrieve Handle Bar Frame		X	0.51	0.58	**0.49**	0.59	0.57	**0.66**	0.61	0.51	0.56
420	Install Handle Bar Frame	X		**0.57**	0.61	0.62	**0.68**	0.59	0.59	0.61	0.6	0.60
430	Install Quick Release S/A and Secure	X		0.2	0.19	**0.18**	0.25	**0.4**	0.26	0.28	0.27	0.24
440	Install Rubber Cover on Quick Release S/A	X		0.49	0.52	**0.49**	0.58	0.55	**0.66**	0.58	0.52	0.54
450	Install Protective Rubber to Seat Post	X		0.74	0.69	0.79	0.75	0.75	0.69	**0.68**	**0.79**	0.74
460	**Walk to Headlight Assembly Workbench**		X	0.58	0.55	0.57	**0.49**	0.61	0.61	**0.62**	0.59	0.59
470	**Assemble Headlight S/A**	X		**12.54**	**11.95**	12.15	12.07	12.05	12.27	12.07	12.11	12.12
480	**Walk Back to Workstation**		X	0.58	0.55	0.57	**0.49**	0.61	0.61	**0.62**	0.59	0.59
490	**Install Headlight S/A onto Handle Bar Frame**	X		**0.34**	0.39	0.36	0.38	0.35	0.36	0.36	**0.4**	0.37
500	Route Wire Harness Up Handle Bar Frame and Secure			1.74	**1.69**	1.78	1.81	1.68	**1.85**	1.76	1.77	1.76

FIGURE 5.5
Continued.

Work Description: Main Assembly				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
510	Install Black Conduit around Wires	X		**0.3**	0.33	**0.38**	0.37	0.34	0.36	0.36	0.34	0.35
520	Walk and Retrieve Ignition		X	0.55	**0.61**	**0.5**	0.54	0.57	0.51	0.54	0.54	0.54
530	Install Ignition to Ignition Cover	X		**0.51**	0.58	**0.66**	0.61	0.59	0.58	0.52	0.65	0.59
540	Remove Back and Front Harness Covers from Plastic Bag		X	0.24	0.25	0.25	0.25	**0.23**	0.28	**0.29**	0.27	0.26
550	Install Back Harness Cover to Front Harness Cover	X		**0.35**	0.38	0.41	0.39	**0.42**	0.39	0.36	0.37	0.38
560	Install Ignition Cover to Front Harness Cover	X		0.47	0.48	0.48	**0.45**	0.51	**0.54**	0.47	0.46	0.48
570	Install Brand Label to Plastic cover	X		**0.1**	0.1	0.1	0.15	0.18	0.11	**0.18**	0.12	0.13
580	Walk and Retrieve LCD Circuit Board		X	0.52	**0.61**	**0.5**	0.55	0.59	0.51	0.54	0.53	0.54
590	Remove Circuit Board from ESD Bag		X	**0.09**	0.1	0.12	0.15	0.18	0.13	**0.18**	0.12	0.13
600	Connect LCD Circuit Board to LCD	X		0.71	**0.69**	0.71	0.74	0.75	0.72	0.74	**0.77**	0.73
610	Remove Back Console Panel from Plastic Bag		X	0.23	0.25	0.27	0.25	**0.23**	0.28	**0.29**	0.26	0.26
620	Install the Back Console Panel to the Headlight S/A	X		0.46	0.48	0.49	**0.44**	0.51	**0.54**	0.47	0.46	0.48
630	Walk and Retrieve Throttle Handle and Adjustable Handle S/A's		X	0.51	**0.61**	**0.5**	0.54	0.57	0.6	0.54	0.59	0.56
640	Connect Throttle Cable to Throttle Handle S/A	X		0.25	0.25	0.26	0.25	**0.22**	0.29	**0.31**	0.26	0.26
650	Insert Throttle Handle to Handle Bar Frame and Secure	X		**0.34**	0.38	0.42	0.39	**0.42**	0.39	0.37	0.37	0.39
660	Connect Brake Cable to Adjustable Handle S/A	X		0.25	0.25	0.26	0.25	**0.22**	0.27	**0.31**	0.26	0.26
670	Insert Adjustable Handle to Handle Bar Frame and Secure	X		**0.35**	0.38	0.41	0.39	**0.42**	0.39	0.36	0.37	0.38
680	Install Trunk Brace	X		1.09	1.14	**1**	**1.18**	1.11	1.12	1.15	1.1	1.12
690	**Walk and Retrieve Trunk S/A**		X	0.55	**0.61**	**0.5**	0.6	0.6	0.51	0.54	0.61	0.57
700	**Install Trunk S/A to Trunk Brace**	X		1.24	1.19	1.28	**1.31**	1.25	1.26	**1.19**	1.22	1.24
710	Connect Bike to Testing Machine		X	0.55	0.55	0.56	**0.52**	**0.61**	0.57	0.52	0.58	0.56
720	Perform Run Test and Inspection		X	2	1.91	**1.85**	**2.15**	2.14	2.05	1.99	1.94	2.01
730	Fill out Run Test Form		X	1	0.95	1.11	**1.12**	**0.94**	1.1	1	1	1.03
740	Disconnect Bike from Testing Machine		X	0.54	0.55	0.57	**0.52**	**0.61**	0.57	0.61	0.58	0.57
750	Place Operator I.D. Label on Electric Motor		X	0.19	0.22	0.2	**0.29**	**0.13**	0.15	0.15	0.16	0.18

FIGURE 5.5
Continued.

Work Description: Main Assembly				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
760	Inflate Tires	X		0.31	0.33	**0.38**	**0.29**	0.35	0.36	0.36	0.34	0.34
770	Move Bike to Packaging Area (Forklift)		X	**0.85**	**1**	0.89	0.94	0.91	0.89	0.88	0.88	0.91
780	Place Bike Helmet on Pallet	X		0.19	0.16	**0.15**	0.17	0.18	**0.2**	0.2	0.16	0.18
790	**Place Mirror on Pallet**	X		0.2	0.15	**0.15**	0.17	0.19	**0.2**	0.19	0.18	0.18
800	**Walk and Retrieve Tool Kit S/A**		X	0.51	0.58	**0.49**	0.59	0.57	**0.66**	0.61	0.51	0.57
810	**Secure Tool Kit S/A to Frame**	X		0.33	0.29	0.31	**0.28**	**0.34**	0.33	0.29	0.36	0.32
820	**Walk and Retrieve Instruction Kit S/A**		X	**0.65**	0.61	0.61	0.57	**0.52**	0.61	0.6	0.61	0.60
830	**Place Instruction Kit S/A on Pallet**	X		0.16	0.16	**0.15**	0.17	0.15	**0.2**	0.2	0.16	0.17
840	Walk and Retrieve Battery Charger		X	**0.65**	0.61	0.59	0.57	**0.53**	0.61	0.62	0.63	0.60
850	Place Battery Charger in Poly Bag	X		0.1	**0.09**	0.11	0.12	0.13	0.11	0.13	**0.13**	0.12
860	Place Battery Charger on Pallet	X		0.2	**0.14**	0.15	0.17	0.16	**0.2**	0.2	0.14	0.17
870	Install (2) Blue Box Holder to Shipping Box	X		0.33	0.36	0.38	0.34	0.36	**0.3**	0.38	**0.39**	0.36
880	Fold Shipping Box		X	0.34	0.29	0.3	**0.28**	**0.34**	0.33	0.29	0.33	0.31
890	Place Shipping Box over Shipping Pallet	X		0.19	0.22	0.2	**0.29**	**0.13**	0.15	0.15	0.16	0.19
900	Staple the Shipping Box to the Shipping Pallet	X		**0.67**	0.74	0.75	**0.76**	0.69	0.71	0.72	0.75	0.72
910	Place Foam Wrap Over Electric Bike and Secure with Tape	X		0.09	**0.09**	0.11	0.12	0.12	0.11	0.12	**0.13**	0.11
920	Fold Top Box		X	0.19	**0.14**	0.16	0.17	0.16	**0.21**	0.2	0.2	0.18
930	Staple Top Box to Shipping Box	X		**0.22**	0.25	**0.26**	0.25	0.25	0.25	0.23	0.22	0.24
940	Install Banding Around Shipping Box	X		1.45	**1.55**	1.48	1.53	1.48	1.44	**1.44**	1.51	1.49
950	Install Packaging Tape over Banding	X		0.25	0.26	**0.29**	**0.2**	0.22	0.22	0.25	0.25	0.24
960	Place Shipping Label on Box	X		0.18	**0.19**	0.15	0.14	**0.13**	0.18	0.18	0.17	0.17
970	Move Finished Product to Shipping Area		X	**1.14**	1.22	**1.25**	1.19	1.17	1.15	1.24	1.24	1.20

FIGURE 5.5
Continued.

Work Description: Instruction Kit				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Place (2) 30 Amp Fuses in Poly Bag	X		0.1	0.1	0.15	0.12	0.14	0.11	0.16	0.16	0.13
20	Place a 5 Amp Fuse In Poly Bag	X		0.15	0.1	0.12	0.15	0.14	0.12	0.16	0.14	0.14
30	Place (3) Keys in Bag	X		0.1	0.16	0.12	0.12	0.11	0.14	0.12	0.16	0.13
40	Place (2) 1/8" x 1" Spacers in Poly Bag	X		0.16	0.1	0.12	0.15	0.14	0.14	0.16	0.14	0.14
50	Place Instruction Manual in Poly Bag	X		0.16	0.15	0.12	0.14	0.11	0.14	0.16	0.15	0.14
60	Place (2) 1/6" x 1/4" Phillip Screw in Poly Bag	X		0.1	0.16	0.12	0.15	0.11	0.14	0.16	0.16	0.14
70	Seal Poly Bag Shut	X		0.1	0.16	0.15	0.12	0.11	0.14	0.16	0.16	0.14

FIGURE 5.6
Instruction kit assembly.

Work Description: Mirror				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Install Mirror Extension to Mirror	X		0.11	0.12	0.15	0.14	**0.09**	0.15	0.15	**0.18**	0.14
20	Install Black Grommet to Mirror Extension	X		**0.15**	0.18	0.16	0.18	0.15	0.18	0.16	**0.18**	0.17
30	Install (1) 7/16" Nut to Mirror Extension	X		0.12	0.12	0.15	0.12	**0.1**	0.15	**0.18**	0.18	0.14
40	Place Mirror in Poly Bag	X		0.18	0.18	0.18	0.18	**0.15**	**0.19**	0.19	0.18	0.18

FIGURE 5.7
Mirror assembly.

Work Description: Tool Kit				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Place 9/16" Wrench in Black Bag	X		**0.1**	0.1	0.12	0.15	0.11	0.14	0.16	**0.16**	0.13
20	Place Large Allen Wrench in Black Bag	X		0.15	**0.1**	0.12	0.15	0.14	0.12	**0.16**	0.14	0.14
30	Place Small Allen Wrench in Black Bag	X		**0.1**	**0.16**	0.12	0.12	0.11	0.14	0.12	0.16	0.13
40	Place Phillip Screw Driver in Black Bag	X		**0.16**	**0.1**	0.12	0.15	0.14	0.14	0.16	0.14	0.14
50	Place Standard Screw Driver in Black Bag	X		**0.16**	0.15	0.12	0.15	**0.11**	0.14	0.14	0.16	0.14
60	Place Hex Wrench in Black Bag	X		0.1	**0.16**	0.12	0.15	**0.11**	0.14	0.16	0.16	0.14

FIGURE 5.8
Tool kit assembly.

Work Description: Trunk				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Remove Trunk Bottom from Plastic Bag		X	**0.06**	0.08	0.1	0.06	**0.11**	0.08	0.09	0.09	0.08
20	Install Lock to Trunk Bottom	X		**0.25**	0.33	0.21	**0.48**	0.41	0.41	0.28	0.26	0.32
30	Remove Trunk Top from Plastic Bag	X	X	0.08	**0.11**	0.09	0.09	**0.06**	0.08	0.08	0.07	0.08
40	Install Red Reflector to Trunk Top	X		0.33	0.3	**0.28**	0.39	0.38	**0.4**	0.31	0.32	0.34
50	Install Lock Bracket to Trunk Top	X		0.3	0.28	**0.27**	0.33	0.33	**0.34**	0.29	0.31	0.31
60	Install Trunk Label to Trunk Top	X		**0.1**	0.1	0.1	0.15	0.18	0.11	**0.18**	0.12	0.13
70	Install Top Trunk to Bottom Trunk	X		0.89	1	0.97	0.92	**1.14**	1.05	**0.88**	0.99	0.97

FIGURE 5.9
Trunk assembly.

Work Description: Main Body Panel				**Time Samples**								AVG
Seq #	**Work Content**	**VA**	**NVA**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
10	Walk and Retrieve Main Body Panel		X	1.14	1.22	**0.12**	1.17	1.25	**1.25**	1.19	1.19	1.19
20	Remove Main Body Panel from Plastic Bag		X	0.25	0.24	**0.29**	0.28	0.25	0.23	0.25	**0.22**	0.25
30	Install Warning Label to Main Body Panel	X		0.18	**0.19**	0.15	0.14	**0.13**	0.18	0.18	0.17	0.17
40	Install Fuse and Fuse Cap	X		**0.15**	**0.19**	0.15	0.18	0.15	0.18	0.15	0.18	0.17
50	Install Charging Adaptor	X		**0.25**	0.24	0.23	0.28	**0.14**	0.18	0.18	0.22	0.22
60	Install Brake Light	X		0.75	0.71	**0.69**	0.74	0.74	0.78	**0.79**	0.74	0.74
70	Install Left Hand Side Signal Light	X		0.66	**0.59**	0.62	0.63	**0.67**	0.65	0.59	0.6	0.63
80	Install Left Hand Side 500Watt Label	X		0.18	**0.19**	0.15	**0.14**	0.15	0.18	0.15	0.18	0.17
90	Install Right Hand Side Signal Light	X		0.66	**0.59**	0.62	0.63	**0.75**	0.65	0.59	0.6	0.63
100	Install Right Hand Side 500Watt Label	X		0.18	**0.19**	0.15	**0.14**	0.16	0.18	0.18	0.18	0.17

FIGURE 5.10
Main body panel assembly.

Total Value-Added Work (VA)	53.48 Min.
Total Nonvalue-Added Work (NVA)	24.33 Min.
Total Work	77.81 Min.
Total Nonvalue-Added Work (NVA) / Total Work	24.33 Min. / 77.81 Min.

Process Design Efficiency = 69%

FIGURE 5.11
Electric bike process design efficiency.

Take some time to familiarize yourself with the work content and the terminology in the time and motion study sheets. This data will be used to explain the entire process of designing and constructing the lean assembly line for building an electric bike. This is a good example of what a time and motion data sheet would look like after eight time samples. Notice the value-added (VA) and the nonvalue-added (NVA) columns. The more Xs in the NVA column, the more waste and interferences in the process. As a visual reference, use a highlighter to mark all the Xs in the NVA column, highlighting all items that need to be addressed.

Now that there is data on the current state of the assembly work, calculate the process design efficiency. Process efficiency is a metric that compares the nonvalue-added work to the value-added work in the line. This is different from productivity. It represents the efficiency of the process, based on the amount of wasted activities that occur. This calculation can be compared to the future process design efficiency. The process design efficiency is calculated in Figure 5.11.

The electric bike line has 31% nonvalue-added work in its current state. Some of this nonvalue-added work is from the testing of the electric motor and the finished bike; however, there is plenty of wasted movement in waiting, walking, and searching for parts. Not all waste will be eliminated from the process, but being in the 10th percentile should be your goal when designing an assembly line.

Collecting time and motion information of an assembly line can take from one to two weeks, depending on the complexity of the product, resources allocated, and the physical length of the line. Once the information is complete, it is good practice to walk the assembly line and do quick comparisons. Show the data to the operators and allow them to make comments or suggestions. If eight samples of each step in the line were documented, the data will probably be quite accurate. The kaizen champion should take the time and motion studies to the next kaizen meeting and present the information to the committee. This kaizen event can now be scheduled.

Chapter Summary

- Select the assembly line or area for the kaizen event.
- Select the team leaders.
- Order supplies and equipment.
- Estimate the cost for conducting the kaizen event.
- Estimate the anticipated results.
- Communicate to the company about the kaizen event in the company newsletter and on the kaizen event communication board.
- Reserve the kaizen team's work area.
- Contact contractors or other external resources.
- Conduct time and motion studies.
- Use a stopwatch to capture the data.
- Document at least eight samples of each work element.
- Involve the operator during time studies.
- Calculate the process designing efficiency from the current state data.
- Process design efficiency of the electric bike line is 69%.

6

Waste Analysis

Current State

Now that the time studies have been done, an analysis of the nonvalue-added work should be conducted. Many manufacturers operate under tremendous levels of waste. The data on the time study collection sheet will provide all the necessary information to begin process improvement ideas. Although WIP (work in process) is not captured during time studies, WIP is very common in today's assembly processes. The closer a company can get to a single piece flow operation, the more proficient they are in running a lean operation. WIP will only create moments of waiting for the operators. Operators may forget which unit they are working on, forget to install parts, or forget to perform essential quality tasks. The main assembly process for the electric bike will be designed for single piece flow, as that is the ideal. In Chapter 4, I discussed the difference between takt time and cycle time. Takt time is the rate at which a single piece flow line must move. Therefore, takt time and single piece flow go hand in hand. Excessive building of WIP has no rhythm, but when establishing single piece flow, the following factors should be considered:

Cycle time versus takt time
Equipment constraints
Changeover time
Material optimization

Cycle Time versus Takt Time

Is the cycle time of a workstation or work cell more than takt time? If the nonvalue-added work has been eliminated and the cycle time cannot be reduced, then single piece flow will be difficult to implement. A good exam-

ple is the speed of a saw. Saws and other equipment are set at a maximum capacity, and the rate at which parts are cut may be more than takt time.

Equipment Constraints

Is the equipment on the line dedicated to one product family? If you are attempting to design a mixed model assembly process, there will problems if a piece of equipment cannot accommodate all the products on the line.

Changeover Time

Quick changeover is a method of analyzing the manufacturing processes and then reducing the materials, resources, and time required for setup. Long changeovers or setups are a major constraint in single piece flow, especially in a mixed model environment. WIP inventories will disappear as changeover times improve. Quick changeovers allow production personnel to respond to changes in product demand. Machine capacity is increased to meet takt time. Simply stated, lead times are reduced.

Material Optimization

Machines and equipment have to be calibrated to process material in the most efficient manner. If the machines are set to meet takt time, but do not take optimization of material into account, scrap and material costs could go up. There has to be a balance between utilizing equipment and meeting takt time. Do not rob from Peter to pay Paul.

Single piece flow focuses the employee's efforts on the manufacturing process, one unit at a time. Reducing WIP allows for this focus. As WIP levels are reduced or eliminated, hidden problems within the process slowly come to light. Single piece flow will reveal items such as poor line balances, poor quality, bad product design, supplier performance, excess handling, poor use of the floor space, and bad leadership decisions. These issues eventually come to the surface, forcing the company to provide resolution. Once the WIP is reduced, the only way to keep the line flowing is to deal with the big issues. Management has no other option.

Waste

There are a variety of opportunities to reduce waste and nonvalue-added work. It is important to look at the order in which work is conducted on the product. The use of a waste analysis form can be very helpful in observing and documenting waste (see Figure 6.1).

Waste Analysis

TEAM: _____
DATE: _____
AREA: _____

	OBSERVATION	ELIMINATION PRIORITY	REASON
1	Defects:		
2	Overproduction:		
3	Inventories:		
4	Motion:		
5	Processing:		
6	Transportation:		
7	Waiting:		

FIGURE 6.1
Waste analysis form.

Nonvalue-added work in the build sequence should be documented on the form. Each wasted element should be given a high, medium, or low priority level, based on how it affects time and safety. An operator walking 30 ft to collect parts would be considered a high priority for elimination, as would any safety concerns when moving heavy parts or units. Medium priority waste should be worked on after high priority issues have been resolved. Low priority waste is generally small in nature and is sometimes deemed necessary to build to product. If an operator spends five seconds moving a unit from one workstation to the next, it would be considered low priority. However, if a company can get to the point where they are eliminating low priority waste, the process design efficiency can be close to 95 to 98%. The individual conducting the time and motion studies should also complete the waste analysis form, so that the information is available for the kaizen team. An alternative approach is to have the kaizen team use this form and perform the waste analysis themselves.

Waste Observation of the Electric Bike Assembly

Look at the time and motion studies. Is the current build sequence in the correct order to promote an efficient and quality-driven process? Are operators struggling to make parts fit because of having to maneuver around large, previously installed parts? A good rule of thumb when analyzing time and motion studies is to look at the time associated with obvious things like walking and retrieving parts, unpackaging parts from suppliers. Remove these nonvalue-added steps from your line-balancing analysis and list them separately. You don't want to design them into your newly balanced line. Part of your implementation plan will be to address this list of newly identified waste and come up with improvement ideas.

Why does installing the bike frame to the shipping pallet in sequence 10 typically take 3 min 15 sec? These are questions that should be answered prior to the kaizen event. Review the nonvalue-added work content on the time study collection sheet to determine why it is occurring.

Main Assembly Line

Walking and Retrieving Parts

Sequence	Nonvalue-added work
10	Walk and retrieve shipping pallet
30	Walk and retrieve front forks
60	Walk and retrieve front wheel
90	Walk and retrieve battery pack
260	Walk and retrieve wire harness
410	Walk and retrieve handlebar frame
520	Walk and retrieve ignition
580	Walk and retrieve LCD circuit board
630	Walk and retrieve throttle and adjustable handle subassemblies (S/A)
840	Walk and retrieve battery charger

Many production floors designate central locations for part storage throughout the assembly line. Rather than paying employees to deliver the material from the stockroom to the line in specific quantities, the receiving department simply brings large quantities of material to these central locations where it is used as required. Companies perceive this process as cost effective because it appears that labor costs are reduced. However, operators that need to leave their workstations to retrieve parts from the central locations create nonvalue-added walk time, while the product on the line sits idle.

To avoid multiple trips, the operator may gather a handful of the same parts and pile them in their station. The entire process is wasted movement that needs to be eliminated. The operator should never have to leave their workstation during the effective hours of work. Material handlers should be employed to ensure that assemblers have the parts and quantities they need, at the appropriate time, and in the right location. All parts should be kept at arms length or behind the operator where they can simply turn to retrieve them.

Removing Parts from Packaging

Sequence	Nonvalue-added work
170	Remove fuse box from box

380	Remove center panel from plastic bag
540	Remove back and front harness covers from plastic bag
590	Remove circuit board from ESD bag
610	Remove back console panel from plastic bag

Many parts and assemblies are delivered to the facility protected by special packaging such as shrink-wrap, boxes, plastic bags, and so forth. If the operator is required to remove the parts from this packaging, they are performing nonvalue-added work. The unpacking of parts and subassemblies from a supplier should be conducted in the receiving area. Removing and disposing of packaging material is more easily done in the receiving area, where there are appropriate places for collecting the discarded packaging. If the removal is done by line operators, floor space would be needed to place the garage bins. Additionally, larger packages would be cumbersome in the workstations, and would require larger garbage bins as well. Operators would be required to leave their workstations to dispose of the packing material, and product on the line would not move at the required takt time. Unpacking of material on the assembly line results in wasted floor space, wasted movement, and lost volume, and therefore, is not a good practice.

There is an exception to this rule. In the case of sequence 590, the operator must remove the circuit board from the ESD bag and must pay special attention to ensure that the circuit board is protected from static discharge. Special ESD boxes and storage containers can help alleviate this problem. The workstation designated for this task should be designed to accommodate this special need.

Walking and Retrieving Subassemblies

Sequence	Nonvalue-added work
290	Walk and retrieve main body panel S/A
460	Walk to headlight assembly workstation
480	Walk back to workstation
690	Walk and retrieve trunk S/A
800	Walk and retrieve tool kit S/A
820	Walk and retrieve instruction kit S/A

Subassemblies can be assembled by a supplier or in-house by operators. Building subassemblies in the facility should be done in a location that is close to the main assembly line stations. There are two ways of accomplishing this. The first method is by using feeder lines, which is an effective solution. Feeder lines are mini-assembly lines that are designed to takt time, and are connected directly to the main assembly line. If the main product has to

move every three minutes, then the subassembly (S/A) must move every three minutes. This process allows the two assemblers to be synchronized. Feeder lines are very good for large subassemblies that cannot be carried; however, they are also effective for smaller parts. If it takes sufficient time to build the subassembly, then a feeder line should be installed, and the subassembly should be built to takt time.

Another approach is to have subassembly work cells established with a team of operators building subassemblies for the main assembly line. This is a common practice, but is usually abused. Operators are often allowed to build as many subassemblies as they want in order to stay busy. To avoid overproduction, it is important to calculate the appropriate number of subassemblies needed at a given time, otherwise known as build quantities. Once these are established, operators are given signals to start and stop building, in order to avoid unnecessary levels of WIP.

In the electric bike work content, operators must walk to retrieve subassemblies, and this is another example of nonvalue-added activity. Although the subassembly work cells may be building to established quantities, the main assembly operators are still leaving their workstations. The resolution is to make material handlers responsible for bringing the finished subassemblies to the main assembly line.

In sequence 460, the operator must walk to retrieve a headlight. This waste could be eliminated by installing a feeder line which would be placed next to the main assembly line workstation that is required to install the headlight.

Testing

Sequence	Nonvalue-added work
120	Connect electric motor to voltage tester
130	Test electric motor
140	Place operator ID label on electric motor
710	Connect bike to testing machine
720	Perform run test and inspection
730	Fill out run test form
740	Disconnect bike from testing machine
750	Place operator ID label on electric motor

Testing and inspection is defined as value added or no value added, depending on the company. Most of my former employers defined testing and inspection as nonvalue-added work. Testing and inspection does not add any inherent value to the product, although it does help ensure that product is built to specifications and is functioning correctly. Whether your company defines testing and inspection as value added or not, it is still a good practice to do them.

It is also wise to keep records of all testing and inspection for future inquiries. For quality assurance, testing operators should also place an identification label on the products that have been tested. For the purposes of this book, testing and inspection will be considered nonvalue-added work in designing the electric bike assembly process.

Miscellaneous Value-Added and Nonvalue-Added Work

Sequence	Value-added and nonvalue-added work
20	Install frame to shipping pallet
470	Assemble headlight S/A
770	Move bike to packaging area (forklift)
880	Fold shipping box
920	Fold top box
970	Move finished product to shipping area

Installing the frame to the shipping pallet in sequence 20 is nonvalue-added work because it requires move time and does not necessarily add value to the product. It only helps prepare the product for assembly and for forklift handling. Refinement of this process should be part of the improvement efforts of the kaizen team.

Although sequence 470 is value added, as stated on the time study collection sheet, it represents a common inefficiency in manufacturing. The main line assembler is required to leave his workstation to assemble the headlight, which is no different than leaving the workstation to collect parts from the central storage area, and ultimately, wasted time. The headlight should be finished and ready for installation. If the standard work for that workstation requires the operator to build the headlight and install it into the finished product, then there should be adequate time to do so and the workstation should be designed with the appropriate tools and parts.

Moving the bike to packaging and to the shipping area in sequences 770 and 970 represent nonvalue-added work. Many facilities have a central packaging area where all parts go to be prepared for shipment. Unless the packaging area has been designed to accommodate the flow of finished products, bottlenecks will occur, slowing all assembly processes. To solve this problem, all assembly lines should have dedicated packaging stations to eliminate moving product from one area to another, to do work that could have been done right on the assembly line.

Another ideal situation is to have the last workstation as close to the shipping dock as possible, so that finished goods can simply be loaded into a delivery trunk. This avoids the accumulation of excess finished goods inventory. It also eliminates the need for operators in the last workstation to move the product to a shipping or staging area. Unless the facility was

specifically designed to carry inventory for distribution purposes, finished product should go directly to the truck, as if it was the next workstation.

The folding of boxes in sequences 880 and 920 does not add value to the product. Installing the boxes does, but how they are prepared for installation is not of any concern to the customer. Most box suppliers deliver their product lying flat on pallets, allowing for easier delivery and handling. It would be difficult and somewhat ridiculous to require a box supplier to deliver the boxes ready for installation. Therefore, the folding of boxes is a good example of nonvalue-added work that may be hard to eliminate. The best way to approach this situation is to design the workstation to accommodate a small quantity of vertically standing boxes, using the least amount of floor space possible.

Establishing single piece flow is the only way to eliminate unnecessary WIP within the assembly line. Assembly lines should be designed to allow the assembler to perform as much value-added work as possible. Reduction or the elimination of waste or nonvalue-added work is the cornerstone of a lean implementation. The kaizen champion should dedicate time to work with operators and engineers in order to identify waste reduction solutions prior to the kaizen event. The kaizen team will perform a variety of process-improvement activities during the event, but some preliminary groundwork can help. Most nonvalue-added work can be eliminated by using common sense. Material stored far away from operators is not logical. Making assemblers leave their station to build subassemblies, when it is not in their standard work, is inefficient. Material that has to be processed by the operator prior to installation does not add value. Product piled up between workstations with no one working on it costs money in wasted inventory and floor space.

Use the time study collection data sheet as the starting point for designing a lean assembly line. It reveals many of the evils that exist within the process and provides all the information needed to balance the work content in the new assembly line workstations.

Future State

It is safe to assume that the "walk and retrieve" elements of the time study collection sheet will be eliminated by placing material and feeder lines right at the workstation. Material handlers will be used to handle parts back and forth from inventory. They will also deliver any non-feeder-line subassemblies to the workstation as needed. Unpacking of material will be done at the receiving dock, not at the workstation. These are simple and easy ways to reduce waste in the future design of our electric bike line. One big difference is that the headlight subassembly will be assembled on a feeder line and not on the main assembly line.

You can assume that these activities will be done during the kaizen event. The kaizen champion can eliminate them from the design and leave the remaining waste reduction activities to the kaizen team during the event. Let's see what happens to the time studies (see Figure 6.2 through Figure 6.8), and the process design efficiency in Figure 6.9, when this nonvalue-added work is removed and the headlight work content is adjusted.

Work Description: Main Assembly				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Install Frame to Shipping Pallet		X	3.24	3.15	3	**2.97**	3.18	3.22	**3.25**	3.2	3.17
20	Install (2) Shock Absorbers to Front Forks	X		0.24	0.26	0.22	0.22	**0.2**	0.29	**0.29**	0.28	0.25
30	Install Front Forks to Frame	X		**0.89**	**0.77**	0.79	0.81	0.85	0.83	0.84	0.81	0.82
40	Install Front Wheel to Front Forks	X		0.33	0.34	**0.3**	0.38	0.38	**0.39**	0.35	0.35	0.36
50	Install (4) Black Rubber Bumpers to Frame	X		0.22	0.26	0.22	**0.29**	**0.2**	0.29	0.29	0.28	0.26
60	Install Battery Pack into Center of Frame	X		**0.64**	0.62	0.61	0.57	**0.55**	0.59	0.61	0.57	0.60
70	Install Serial Number Label to Frame	X		**0.18**	**0.13**	0.16	0.16	0.13	0.15	0.15	0.15	0.15
80	Connect Electric Motor to Voltage Tester		X	0.55	0.55	0.56	**0.52**	**0.61**	0.57	0.52	0.58	0.56
90	Test Electric Motor		X	**1.15**	1.22	1.23	1.3	**1.31**	1.28	1.19	1.25	1.25
100	Place Operator I.D. Label on Electric Motor		X	0.19	0.22	0.2	**0.29**	**0.13**	0.15	0.15	0.16	0.18
110	Remove Electric Motor from Voltage Tester		X	**0.49**	0.55	0.55	0.52	**0.63**	0.57	0.55	0.58	0.55
120	Install Electric Motor to Frame	X		**0.62**	0.68	**0.71**	0.63	0.64	0.64	0.66	0.7	0.66
130	Install Fuse Box to Frame	X		**0.48**	0.55	**0.63**	0.52	0.63	0.55	0.55	0.57	0.56
140	Install Horn to Frame	X		**0.31**	0.25	0.26	0.29	0.3	0.28	**0.23**	0.26	0.27
150	Install Drive Chain to Electric Motor	X		**0.18**	0.18	0.16	0.16	**0.14**	0.14	0.15	0.15	0.16
160	Install Rear Wheel Assembly and Wrap Drive Chain around Sprocket	X		0.88	0.95	0.87	**0.85**	0.94	0.92	0.95	**1**	0.92
170	Route Brake Cable from Rear Wheel and Secure	X		1.24	1.19	1.21	**1.26**	1.2	**1.18**	1.18	1.24	1.21

FIGURE 6.2
Main assembly.

Continued.

Work Description: Main Assembly				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
180	Route Throttle Cable from Rear Wheel and Secure	X		1.21	1.18	1.21	**1.26**	1.2	**1.18**	1.22	1.26	1.21
190	Secure Rear Wheel Assembly	X		1.89	2	1.95	1.92	**2.05**	**1.87**	1.98	1.91	1.94
200	Attach Brake Cable to Brake Drum and Adjust Tension	X		0.71	**0.69**	0.75	0.76	0.74	**0.78**	0.69	0.7	0.73
210	Install and Connect Wire Harness	X		**3.74**	3.65	3.7	3.64	**3.48**	3.49	3.58	3.55	3.60
220	Secure Wire Harness Wires	X		1.3	1.28	**1.2**	1.35	1.27	1.39	**1.4**	1.28	1.31
230	**Install Main Body S/A**	X		**0.95**	1.14	0.99	1.05	1.1	0.97	0.98	**1.18**	1.04
240	Install Black Grommet on Back Suspension	X		0.18	0.16	**0.11**	0.12	**0.19**	0.14	0.15	0.15	0.15
250	Install (2) 1" Lock Nuts Over Black Grommet	X		0.3	0.33	**0.29**	0.35	0.35	0.3	0.33	**0.38**	0.33
260	Install Black Grommet on Front Forks	X		0.11	0.16	**0.11**	0.12	**0.19**	0.19	0.15	0.15	0.15
270	Install (2) 1" Lock Nuts Over Black Grommet	X		0.31	0.32	**0.28**	0.35	0.37	0.3	0.33	**0.38**	0.33
280	Install Seat Post to Main Body Frame	X		0.18	0.16	**0.11**	0.12	**0.19**	0.14	0.15	0.15	0.15
290	Install Seat Cushion to Post	X		0.64	0.68	**0.59**	**0.71**	0.64	0.61	0.6	0.6	0.63
300	Install Seat Quick Release S/A	X		0.22	0.19	**0.19**	0.25	**0.27**	0.21	0.21	0.27	0.23
310	Install Center Panel Lock To Center Panel	X		**0.25**	0.33	0.21	**0.48**	0.41	0.41	0.28	0.26	0.32
320	Install Center Panel to Main Body Panel	X		0.21	0.19	0.2	**0.18**	0.23	0.26	**0.28**	0.23	0.22
330	Install Handle Bar Frame	X		**0.57**	0.61	0.62	**0.68**	0.59	0.59	0.61	0.6	0.60
340	Install Quick Release S/A and Secure	X		0.2	0.19	**0.18**	0.25	**0.4**	0.26	0.28	0.27	0.24
350	Install Rubber Cover on Quick Release S/A	X		0.49	0.52	**0.49**	0.58	0.55	**0.66**	0.58	0.52	0.54
360	Install Protective Rubber to Seat Post	X		0.74	0.69	0.79	0.75	0.75	0.69	**0.68**	**0.79**	0.74
370	**Install Headlight S/A onto Handle Bar Frame**	X		**0.34**	0.39	0.36	0.38	0.35	0.36	0.36	**0.4**	0.37
380	Route Wire Harness Up Handle Bar Frame and Secure			1.74	**1.69**	1.78	1.81	1.68	**1.85**	1.76	1.77	1.76

FIGURE 6.2
Continued.

Work Description: Main Assembly				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
390	Install Black Conduit around Wires	X		**0.3**	0.33	**0.38**	0.37	0.34	0.36	0.36	0.34	0.35
400	Install Ignition to Ignition Cover	X		**0.51**	0.58	**0.66**	0.61	0.59	0.58	0.52	0.65	0.59
410	Install Back Harness Cover to Front Harness Cover	X		**0.35**	0.38	0.41	0.39	**0.42**	0.39	0.36	0.37	0.38
420	Install Ignition Cover to Front Harness Cover	X		0.47	0.48	0.48	**0.45**	0.51	**0.54**	0.47	0.46	0.48
430	Install Brand Label to Plastic cover	X		**0.1**	0.1	0.1	0.15	0.18	0.11	**0.18**	0.12	0.13
440	Connect LCD Circuit Board to LCD	X		0.71	**0.69**	0.71	0.74	0.75	0.72	0.74	**0.77**	0.73
450	Install the Back Console Panel to the Headlight S/A	X		0.46	0.48	0.49	**0.44**	0.51	**0.54**	0.47	0.46	0.48
460	Connect Throttle Cable to Throttle Handle S/A	X		0.25	0.25	0.26	0.25	**0.22**	0.29	**0.31**	0.26	0.26
470	Insert Throttle Handle to Handle Bar Frame and Secure	X		**0.34**	0.38	0.42	0.39	**0.42**	0.39	0.37	0.37	0.39
480	Connect Brake Cable to Adjustable Handle S/A	X		0.25	0.25	0.26	0.25	**0.22**	0.27	**0.31**	0.26	0.26
490	Insert Adjustable Handle to Handle Bar Frame and Secure	X		**0.35**	0.38	0.41	0.39	**0.42**	0.39	0.36	0.37	0.38
500	Install Trunk Brace	X		1.09	1.14	**1**	**1.18**	1.11	1.12	1.15	1.1	1.12
510	**Install Trunk S/A to Trunk Brace**	X		1.24	1.19	1.28	**1.31**	1.25	1.26	**1.19**	1.22	1.24
520	Connect Bike to Testing Machine		X	0.55	0.55	0.56	**0.52**	**0.61**	0.57	0.52	0.58	0.56
530	Perform Run Test and Inspection		X	2	1.91	**1.85**	**2.15**	2.14	2.05	1.99	1.94	2.01
540	Fill out Run Test Form		X	1	0.95	1.11	**1.12**	**0.94**	1.1	1	1	1.03
550	Disconnect Bike from Testing Machine		X	0.54	0.55	0.57	**0.52**	**0.61**	0.57	0.61	0.58	0.57
560	Place Operator I.D. Label on Electric Motor		X	0.19	0.22	0.2	**0.29**	**0.13**	0.15	0.15	0.16	0.18

FIGURE 6.2
Continued.

Work Description: Main Assembly				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
570	Inflate Tires	X		0.31	0.33	**0.38**	**0.29**	0.35	0.36	0.36	0.34	0.34
580	Place Bike Helmet on Pallet	X		0.19	0.16	**0.15**	0.17	0.18	**0.2**	0.2	0.16	0.18
590	**Place Mirror on Pallet**	X		0.2	0.15	**0.15**	0.17	0.19	**0.2**	0.19	0.18	0.18
600	**Secure Tool Kit S/A to Frame**	X		0.33	0.29	0.31	**0.28**	**0.34**	0.33	0.29	0.36	0.32
610	**Place Instruction Kit S/A on Pallet**	X		0.16	0.16	**0.15**	0.17	0.15	**0.2**	0.2	0.16	0.17
620	Place Battery Charger in Poly Bag	X		0.1	**0.09**	0.11	0.12	0.13	0.11	0.13	**0.13**	0.12
630	Place Battery Charger on Pallet	X		0.2	**0.14**	0.15	0.17	0.16	**0.2**	0.2	0.14	0.17
640	Install (2) Blue Box Holder to Shipping Box	X		0.33	0.36	0.38	0.34	0.36	**0.3**	0.38	**0.39**	0.36
650	Fold Shipping Box		X	0.34	0.29	0.3	**0.28**	**0.34**	0.33	0.29	0.33	0.31
660	Place Shipping Box over Shipping Pallet	X		0.19	0.22	0.2	**0.29**	**0.13**	0.15	0.15	0.16	0.19
670	Staple the Shipping Box to the Shipping Pallet	X		**0.67**	0.74	0.75	**0.76**	0.69	0.71	0.72	0.75	0.72
680	Place Foam Wrap Over Electric Bike and Secure with Tape	X		0.09	**0.09**	0.11	0.12	0.12	0.11	0.12	**0.13**	0.11
690	Fold Top Box		X	0.19	**0.14**	0.16	0.17	0.16	**0.21**	0.2	0.2	0.18
700	Staple Top Box to Shipping Box	X		**0.22**	0.25	**0.26**	0.25	0.25	0.25	0.23	0.22	0.24
710	Install Banding Around Shipping Box	X		1.45	**1.55**	1.48	1.53	1.48	1.44	**1.44**	1.51	1.49
720	Install Packaging Tape over Banding	X		0.25	0.26	**0.29**	**0.2**	0.22	0.22	0.25	0.25	0.24
730	Move Finished Product to Shipping Area		X	**1.14**	1.22	**1.25**	1.19	1.17	1.15	1.24	1.24	1.20

FIGURE 6.2
Continued.

Work Description: Instruction Kit				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Place (2) 30 Amp Fuses in Poly Bag	X		**0.1**	0.1	0.15	0.12	0.14	0.11	0.16	**0.16**	0.13
20	Place a 5 Amp Fuse In Poly Bag	X		0.15	**0.1**	0.12	0.15	0.14	0.12	**0.16**	0.14	0.14
30	Place (3) Keys in Bag	X		**0.1**	**0.16**	0.12	0.12	0.11	0.14	0.12	0.16	0.13
40	Place (2) 1/8" x 1" Spacers in Poly Bag	X		**0.16**	**0.1**	0.12	0.15	0.14	0.14	0.16	0.14	0.14
50	Place Instruction Manual in Poly Bag	X		**0.16**	0.15	0.12	0.14	**0.11**	0.14	0.16	0.15	0.14
60	Place (2) 1/16" x 1/4" Phillip Screw in Poly Bag	X		0.1	**0.16**	0.12	0.15	**0.11**	0.14	0.16	0.16	0.14
70	Seal Poly Bag Shut	X		0.1	**0.16**	0.15	0.12	**0.11**	0.14	0.16	0.16	0.14

FIGURE 6.3
Instruction kit assembly.

Work Description: Mirror				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Install Mirror Extension to Mirror	X		0.11	0.12	0.15	0.14	**0.09**	0.15	0.15	**0.18**	0.14
20	Install Black Grommet to Mirror Extension	X		**0.15**	0.18	0.16	0.18	0.15	0.18	0.16	**0.18**	0.17
30	Install (1) 7/16" Nut to Mirror Extension	X		0.12	0.12	0.15	0.12	**0.1**	0.15	**0.18**	0.18	0.14
40	Place Mirror in Poly Bag	X		0.18	0.18	0.18	0.18	**0.15**	**0.19**	0.19	0.18	0.18

FIGURE 6.4
Mirror assembly.

Work Description: Tool Kit				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Place 9/16" Wrench in Black Bag	X		**0.1**	0.1	0.12	0.15	0.11	0.14	0.16	**0.16**	0.13
20	Place Large Allen Wrench in Black Bag	X		0.15	**0.1**	0.12	0.15	0.14	0.12	**0.16**	0.14	0.14
30	Place Small Allen Wrench in Black Bag	X		**0.1**	**0.16**	0.12	0.12	0.11	0.14	0.12	0.16	0.13
40	Place Phillip Screw Driver in Black Bag	X		**0.16**	**0.1**	0.12	0.15	0.14	0.14	0.16	0.14	0.14
50	Place Standard Screw Driver in Black Bag	X		**0.16**	0.15	0.12	0.15	**0.11**	0.14	0.14	0.16	0.14
60	Place Hex Wrench in Black Bag	X		0.1	**0.16**	0.12	0.15	**0.11**	0.14	0.16	0.16	0.14

FIGURE 6.5
Tool kit assembly.

Work Description: Trunk				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Install Lock to Trunk Bottom	X		**0.25**	0.33	0.21	**0.48**	0.41	0.41	0.28	0.26	0.32
20	Install Red Reflector to Trunk Top	X		0.33	0.3	**0.28**	0.39	0.38	**0.4**	0.31	0.32	0.34
30	Install Lock Bracket to Trunk Top	X		0.3	0.28	**0.27**	0.33	0.33	**0.34**	0.29	0.31	0.31
40	Install Trunk Label to Trunk Top	X		**0.1**	0.1	0.1	0.15	0.18	0.11	**0.18**	0.12	0.13
50	Install Top Trunk to Bottom Trunk	X		0.89	1	0.97	0.92	**1.14**	1.05	**0.88**	0.99	0.97

FIGURE 6.6
Trunk assembly.

Work Description: Main Body Panel				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Install Warning Label to Main Body Panel	X		0.18	**0.19**	0.15	0.14	**0.13**	0.18	0.18	0.17	0.17
20	Install Fuse and Fuse Cap	X		**0.15**	**0.19**	0.15	0.18	0.15	0.18	0.15	0.18	0.17
30	Install Charging Adaptor	X		**0.25**	0.24	0.23	0.28	**0.14**	0.18	0.18	0.22	0.22
40	Install Brake Light	X		0.75	0.71	**0.69**	0.74	0.74	0.78	**0.79**	0.74	0.74
50	Install Left Hand Side Signal Light	X		0.66	**0.59**	0.62	0.63	**0.67**	0.65	0.59	0.6	0.63
60	Install Left Hand Side 500 Watt Label	X		0.18	**0.19**	0.15	**0.14**	0.15	0.18	0.15	0.18	0.17
70	Install Right Hand Side Signal Light	X		0.66	**0.59**	0.62	0.63	**0.75**	0.65	0.59	0.6	0.63
80	Install Right Hand Side 500 Watt Label	X		0.18	**0.19**	0.15	**0.14**	0.16	0.18	0.18	0.18	0.17

FIGURE 6.7
Main body panel assembly.

Work Description: Headlight				Time Samples								AVG
Seq #	Work Content	VA	NVA	1	2	3	4	5	6	7	8	
10	Install Left Hand Side Signal Reflector to Headlight Panel	X		0.55	**0.62**	0.57	0.52	0.61	**0.49**	0.52	0.53	0.55
20	Install Headlight Reflector to Headlight Panel	X		0.52	0.49	**0.48**	**0.59**	0.59	0.52	0.55	0.57	0.54
30	Install Right Hand Side Signal Reflector to Headlight Panel	X		0.51	**0.62**	0.59	0.52	0.62	**0.49**	0.52	0.54	0.55
40	Install (2) Signal Bulbs to Light Module	X		0.16	**0.18**	0.16	**0.12**	0.15	0.17	0.18	0.18	0.17
50	Install (1) Headlight Bulb to Light Module	X		0.08	0.09	0.08	**0.07**	0.07	0.08	0.09	**0.09**	0.08
60	Install Light Module to Headlight Panel	X		0.32	0.3	0.28	**0.35**	0.3	0.3	**0.27**	0.33	0.31
70	Connect Headlight Wire Harness to Light Module	X		6.58	6.74	6.48	6.55	**6.25**	6.49	6.74	**6.81**	6.60
80	Secure Wires	X		3.14	**3.57**	3.25	**2.98**	3.27	3.05	3.51	3.46	3.28

FIGURE 6.8
Headlight assembly.

Total Value-Added Work (VA)	53.48 Min.
Total Nonvalue-Added Work (NVA)	11.75 Min.
Total Work	65.23 Min.
Total Nonvalue-Added Work (NVA) / Total Work	11.75 Min. / 65.23 Min.
New Process Design Efficiency	= 82%

FIGURE 6.9
Future state process design efficiency.

As you can see, by eliminating the time it took to walk and retrieve parts, remove packaging material, and move the bike to and from packaging and shipping, we increased the process design efficiency to 82%. There is still room for improvement, and the kaizen team will address other waste during the kaizen event. The information left on the time study collection sheets can now be used to start the first new line balancing efforts. Just remember that the nonvalue-added activities from the current state data has to be eliminated during the event, so it would be smart to have the original time study sheets available for the kaizen team to use as reference.

Chapter Summary

- Single piece flow is the most ideal situation on an assembly line.
- Use a waste analysis form to document nonvalue-added work and apply a high, medium, or low priority.
- Time and safety should be used when prioritizing waste.
- Placing parts at point of use in the workstation will reduce a lot of nonvalue-added work.
- Removing parts from packaging back in the receiving area will increase the flow of the line.
- Subassemblies should be complete so the operator can install them into the unit.
- It is safe to remove the walking work content from the time and motion studies with the assumption that material will be placed near the workstation.
- Removing the time it takes to walk for parts and unwrapping parts on the line, the process design efficiency for the electric bike increased to 82%.

7

Two Weeks to Go

The kaizen event is coming up quickly. The kaizen champion has some work to do at this point and will need to levy help from the members of the kaizen governing committee (see Figure 7.1).

Select the Kaizen Team Members

A temporary list of potential team members was originated during the kaizen monthly meeting, and the kaizen champion should get with the team leader and pick the team. Vacation schedules should be verified with the human resources department to ensure that the team members will be in the plant for the event.

After the kaizen champion and the team leader have selected the team members, they should go around the plant and let team members' managers know of their participation. After the list has been finalized, it should be placed on the kaizen event communication board. Employees picked for the event may have outside responsibilities with family that should be considered. Allow the team members a few days to check with their families if they can work the shift that has been chosen. Let the team members know that food and beverages will be provided during the event.

Get an Update on Supplies and Equipment

A variety of items were ordered and certain contractors may have been reserved for the kaizen event. The kaizen champion should verify that these items have been taken care of and get a status report. There may be particular supplies or equipment that are critical to the kaizen team that may be back-ordered or unavailable. If the absence of an item will create problems for

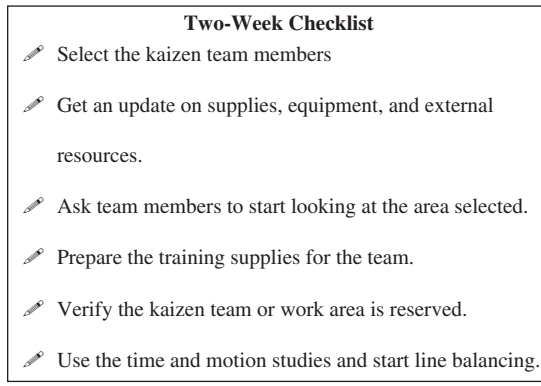


FIGURE 7.1
Two-week checklist.

the team, the kaizen champion may need to postpone the event. Make an educated decision if the event should continue or come up with alternatives.

Miscellaneous Preparation

Team members should spend some time on the assembly line or area that has been chosen for the kaizen event. They should start talking to operators and write ideas for the event. It is good practice for the team to do this, so the operators become familiar with them. It will help promote a sense of trust, and the operators will be more inclined to listen to their ideas. The team should do this up until the start of the event.

The team leader should start to put together the training material for the team. Each kaizen team should be given an overview of kaizen, kaizen events, the seven wastes, 5S, standard work, and visual management. Overheads, handouts, slide presentations, or any other form of training material has to be prepared for the team's training. The kaizen champion should check that the team work area or conference room has been reserved and that it will cleaned out and prepared for the team.

Line Balancing

By now, your kaizen governing committee should have scheduled the kaizen event and selected the team leader for the electric bike line. Preparation

510 Minutes	Total Time in the Facility
−30 Minutes	Lunch (Not Paid)
−20 Minutes	Two Coffee Breaks
−15 Minutes	Morning Meeting
−15 Minutes	End of Day Cleanup and 5S
−20 Minutes	Day-to-Day Kaizen Activity
410 Minutes	Effective Hours

Electric Bike Daily Volume Requirements = 72

FIGURE 7.2
Calculation of effective hours and volume.

should be made to ensure that the team members' usual responsibilities will be covered by someone else in the plant. It is time now to start line balancing

Balancing work content in an assembly process can be quite easy at times because the work can be split up into very small elements. There are a few occurrences when balancing an assembly process does not require rigorous time and motion studies. Relieving bottlenecks in line flow can be done by simply watching the interaction between assemblers for a short moment of time. This works well if the changes are to be made at the moment of observation. However, full implementation of 5S, standard work, and visual management requires a much more detailed approach in line balancing and workstation design. This is where dedicated effort to collect time and motion data is critical. Errors in the time and motion analysis will quickly surface within hours of starting up a new assembly line.

Before line balancing can occur, we need to establish the volume requirements and the effective hours of the line. The kaizen champion will probably not have a lot of input when it comes to these items. As mentioned before, these numbers are associated with operational decisions like holidays, shifts, forecasting, historical data, breaks, and so forth. For the purposes of designing our electric bike line, the effective hours and volume requirements shown in Figure 7.2 will be used.

In a mixed model environment it is important to consider all product models that will be running on the assembly line. Different products need to flow at the same takt time as if they were running on a single model assembly line. Line balancing on a mixed model line is no different than single model lines. There will be a variety of differences and options from one model to the next, but the time study work and line balancing activities are identical.

Now that we have the daily volume requirements and effective hours established, the next step is to calculate takt time (see Figure 7.3).

$$\text{Takt Time (T)} = \frac{\text{Effective Hours x \# of Shifts (t)}}{\text{Product Volume}}$$

$$\text{Takt Time} = \frac{\text{410 Minutes x 1 Shift}}{\text{72 Units/Day}}$$

$$\text{Takt Time} = \frac{410(1)}{72}$$

$$\text{Takt Time} = 5.69 \text{ Minutes}$$

FIGURE 7.3
Electric bike line takt time.

The electric bike line has to produce a finished product every 5.69 min in one shift. Remember that the 5.69-min requirement would be working assemblers at a 100% pace. This does not lend itself to good productivity and quality in the long run. The 85% rule needs to be applied to ensure that assemblers are allowed to work a nice smooth, consistent pace.

Multiplying 5.69 min by 85% gives a takt time of 4.84 min.

The workstations will be balanced as close to 4.84 min as possible. It is very rare that all assembly operations are all loaded exactly to the required takt time. No workstation should be loaded higher than 4.84 min because the line will simply be unable to meet the end-of-day requirements, or quality may suffer because the pace would not be 85%.

Resource Requirements

A 4.84 min takt time is a good efficient pace. Long takt times create design challenges for the kaizen team because assemblers can become bored with the slow pace. Short takt times, like less than a minute, could fatigue and overwhelm the operator even when the 85% rule is applied. I am aware than certain companies have low output requirements, and long takt times are simply a way of life. Short takt times can be extended by adding a second shift to the operation. Although it requires resources to support a second shift operation, less floor space would be used, opening an area for a future product.

Now that takt time has been calculated, all design efforts should center on it. An electric bike has to come off the assembly line and product needs to flow in and out of workstations every 4.84 min. Calculate the required workstations that will be needed to support takt time (see Figure 7.4). Take the total time from each time study collection sheet and divide these totals by 4.84 min.

The number of workstations calculated should be rounded to the next whole number. The workstation requirements for the main assembly line

Electric Bike Main Assembly	
Unit	**Qty (Units)**
Electric Bike	**72**
Effective Hours	**410**
Cycle Time	**5.69**
Takt Time (85%)	**4.84**
Assembly Time	**46.09**
Number of Workstations	**9.52**

Tool Kit Assembly	
Unit	**Qty (Units)**
Tool Kit	**72**
Effective Hours	**410**
Cycle Time	**5.69**
Takt Time (85%)	**4.84**
Assembly Time	**0.82**
Number of Workstations	**0.17**

Headlight Assembly	
Unit	**Qty (Units)**
Headlight	**72**
Effective Hours	**410**
Cycle Time	**5.69**
Takt Time (85%)	**4.84**
Assembly Time	**12.07**
Number of Workstations	**2.49**

Mirror Assembly	
Unit	**Qty (Units)**
Mirror	**72**
Effective Hours	**410**
Cycle Time	**5.69**
Takt Time (85%)	**4.84**
Assembly Time	**0.63**
Number of Workstations	**0.13**

Trunk Assembly	
Unit	**Qty (Units)**
Trunk	**72**
Effective Hours	**410**
Cycle Time	**5.69**
Takt Time (85%)	**4.84**
Assembly Time	**2.06**
Number of Workstations	**0.43**

Instruction Kit Assembly	
Unit	**Qty (Units)**
Instruction Kit	**72**
Effective Hours	**410**
Cycle Time	**5.69**
Takt Time (85%)	**4.84**
Assembly Time	**0.96**
Number of Workstations	**0.20**

Main Body Panel	
Unit	**Qty (Units)**
Main Body Panel	**72**
Effective Hours	**410**
Cycle Time	**5.69**
Takt Time (85%)	**4.84**
Assembly Time	**2.88**
Number of Workstations	**0.60**

FIGURE 7.4
Electric bike line workstation requirements.

came to 9.52 stations. Since there is no such thing as a half station, there will be ten stations. The headlight subassembly will have three stations and is a perfect candidate for a feeder line.

The remaining subassemblies require less than one station for each assembly. Depending on where they are installed, subassembly work cells will be set up for their assembly. The kaizen team will have to create build quantity levels and other visual signals to ensure that operators do not overbuild. The material handlers can bring them to the main assembly line.

Balancing the line is about distributing the work content through the required resources to ensure a nice even flow of product through the line. There are a few simple rules to follow that will allow for a nice even line. This is a good opportunity to have a line lead or equivalent representative from the assembly line who can help. Their input can be helpful in avoiding moving work content to the wrong section of the flow line. Use these four rules, in order, when balancing the line.

Eliminate nonvalue-added work
Balance by time
Balance by work content
Balance by material

Eliminate Nonvalue-Added Work

Analysis of the time and motion studies will identify opportunities for waste removal. Much of the nonvalue-added work that was identified in the time and motion studies was conceptually removed. It is never a good idea to design waste into the assembly line. Remember, it is safe to assume that the kaizen team will design the workstations for point-of-use material and subassemblies. All the required tools, supplies, equipment, and documentation will be at the workstations so the operator will never have to leave their work area during the effective hours. The kaizen team will conduct a variety of waste reduction activities during the kaizen event that will enable the line to flow properly. Use the time and motion data to help direct you into the right direction.

Balance by Time

Time is the key. Conduct the first pass at line balancing by simply adding the times together as you go down the time study collection sheet. It will be difficult to add up work content that equals 4.84 min on the first pass. When adding

these times together, never go over 5.69 min, since that is the absolute maximum. Although a pace of 5.69 min will enable the line to produce the required 72 bikes, always stay focused on balancing to 4.84 min. Remember this is a first pass and the other line balancing rules will help you as the balancing exercise continues. The main assembly time balance is shown in Figure 7.5 through Figure 7.14, and the headlight time balance is shown in Figure 7.15.

As you can see, some of the work content balanced very well during the time balance. Workstations 1, 2, and 3 balanced very close to 4.84 min. However, the remaining workstations will require more line balancing. Workstation 4 has only 2.67 min worth of work, which is well below takt time. If this workstation were left as is, the operator assigned to it would be waiting nearly half the time.

The other workstation that stands out is workstation 10, where the electric bike is packaged for shipping. A cycle time of 6.18 min will create problems for the assembly line. If this station were to stay unfixed, the assembly line would only be able to produce 66 units a day. The next step in the line balancing exercise is to balance by work content.

Workstation 1		
Seq#	**Work Content**	**Time**
10	Install Frame to Shipping Pallet	3.17
20	Install (2) Shock Absorbers to Front Forks	0.25
30	Install Front Forks to Frame	0.82
40	Install Front Wheel to Front Forks	0.36
	Total	**4.60**

FIGURE 7.5
Workstation 1.

Workstation 2		
Seq #	**Work Content**	**Time**
50	Install (4) Black Rubber Bumpers to Frame	0.26
60	Install Battery Pack into Center of Frame	0.60
70	Install Serial Number Label to Frame	0.15
80	Connect Electric Motor to Voltage Tester	0.56
90	Test Electric Motor	1.25
100	Place Operator I.D. Label on Electric Motor	0.18
110	Remove Electric Motor from Voltage Tester	0.55
120	Install Electric Motor to Frame	0.66
	Total	**4.21**

FIGURE 7.6
Workstation 2.

Workstation 3		
Seq #	**Work Content**	**Time**
130	Install Fuse Box to Frame	0.56
140	Install Horn to Frame	0.27
150	Install Drive Chain to Electric Motor	0.16
160	Install Rear Wheel Assembly and Wrap Drive Chain around Sprocket	0.92
170	Route Brake Cable from Rear Wheel and Secure	1.21
180	Route Throttle Cable from Rear Wheel and Secure	1.21
	Total	**4.33**

FIGURE 7.7
Workstation 3.

Workstation 4		
Seq #	**Work Content**	**Time**
190	Secure Rear Wheel Assembly	1.94
200	Attach Brake Cable to Brake Drum and Adjust Tension	0.73
	Total	**2.67**

FIGURE 7.8
Workstation 4.

Workstation 5		
Seq #	**Work Content**	**Time**
210	Install and Connect Wire Harness	3.60
220	Secure Wire Harness Wires	1.31
	Total	**4.91**

FIGURE 7.9
Workstation 5.

Workstation 6		
Seq#	**Work Content**	**Time**
230	Install Main Body Panel S/A	1.04
240	Install Black Grommet on Back Suspension	0.15
250	Install (2) 1" Lock Nuts Over Black Grommet	0.33
260	Install Black Grommet on Front Forks	0.15
270	Install (2) 1" Lock Nuts Over Black Grommet	0.33
280	Install Seat Post to Main Body Frame	0.15
290	Install Seat Cushion to Post	0.63
300	Install Seat Quick Release S/A	0.23
310	Install Center Panel Lock To Center Panel	0.32
320	Install Center Panel to Main Body Panel	0.22
330	Install Handle Bar Frame	0.60
340	Install Quick Release S/A and Secure	0.24
	Total	**4.39**

FIGURE 7.10
Workstation 6.

Workstation 7		
Seq#	**Work Content**	**Time**
350	Install Rubber Cover on Quick Release S/A	0.54
360	Install Protective Rubber to Seat Post	0.74
370	Install Headlight S/A onto Handle Bar Frame	0.37
380	Route Wire Harness Up Handle Bar Frame and Secure	1.76
390	Install Black Conduit around Wires	0.35
400	Install Ignition to Ignition Cover	0.59
410	Install Back Harness Cover to Front Harness Cover	0.38
	Total	**4.73**

FIGURE 7.11
Workstation 7.

Workstation 8		
Seq #	**Work Content**	**Time**
420	Install Ignition Cover to Front Harness Cover	0.48
430	Install Brand Label to Plastic cover	0.13
440	Connect LCD Circuit Board to LCD	0.73
450	Install the Back Console Panel to the Headlight S/A	0.48
460	Connect Throttle Cable to Throttle Handle S/A	0.26
470	Insert Throttle Handle to Handle Bar Frame and Secure	0.39
480	Connect Brake Cable to Adjustable Handle S/A	0.26
490	Insert Adjustable Handle to Handle Bar Frame and Secure	0.38
500	Install Trunk Brace	1.12
	Total	**4.23**

FIGURE 7.12
Workstation 8.

Workstation 9		
Seq#	**Work Content**	**Time**
510	Install Trunk S/A to Trunk Brace	1.24
520	Connect Bike to Testing Machine	0.56
530	Perform Run Test and Inspection	2.01
540	Fill out Run Test Form	1.03
550	Disconnect Bike from Testing Machine	0.57
560	Place Operator I.D. Label on Electric Motor	0.18
570	Inflate Tires	0.34
	Total	**5.93**

FIGURE 7.13
Workstation 9.

Workstation 10		
Seq #	**Work Content**	**Time**
580	Place Bike Helmet on Pallet	0.18
590	Place Mirror on Pallet	0.18
600	Secure Tool Kit S/A to Frame	0.32
610	Place Instruction Kit S/A on Pallet	0.17
620	Place Battery Charger in Poly Bag	0.12
630	Place Battery Charger on Pallet	0.17
640	Install (2) Blue Box Holder to Shipping Box	0.36
650	Fold Shipping Box	0.31
660	Place Shipping Box over Shipping Pallet	0.19
670	Staple the Shipping Box to the Shipping Pallet	0.72
680	Place Foam Wrap Over Electric Bike and Secure with Tape	0.11
690	Fold Top Box	0.18
700	Staple Top Box to Shipping Box	0.24
710	Install Banding Around Shipping Box	1.49
720	Install Packaging Tape over Banding	0.24
730	Move Finished Product to Shipping Area	1.20
	Total	**6.18**

FIGURE 7.14
Workstation 10.

Head Light Station 1		
Seq #	**Work Content**	**Time**
10	Install Left Hand Side Signal Reflector to Headlight Panel	0.55
20	Install Headlight Reflector to Headlight Panel	0.54
30	Install Right Hand Side Signal Reflector to Headlight Panel	0.55
40	Install (2) Signal Bulbs to Light Module	0.17
50	Install (1) Headlight Bulb to Light Module	0.08
60	Install Light Module to Headlight Panel	0.31
	Total	**2.20**

Head Light Station 2		
Seq #	**Work Content**	**Time**
70	Connect Headlight Wire Harness to Light Module	6.60
	Total	**6.60**

Head Light Station 3		
Seq #	**Work Content**	**Time**
80	Secure Wires	3.28
	Total	**3.28**

FIGURE 7.15
Headlight workstations.

Balance by Work Content

Manual assembly work can be separated into the smallest and simplest tasks. Installing a bracket with four screws can be broken into four separate operations if needed. One operator could install one screw; the next operator could install another screw, and so on. This allows the person balancing the assembly line to distribute work content very close to takt time. If a wire harness includes ten wires, the installation can be divided in a variety of ways. The wire harness does not necessarily have to be installed all at once unless there is a safety concern.

However, there is a disadvantage to this process. By separating work content into tiny increments, a part may be secured incorrectly, causing a quality problem. In the case of a wire harness, wires could hang over other parts while moving downstream, creating opportunities for crimping. Just be careful how much work content is broken down, and if a part can be fully installed without disturbing takt time, the better off you are.

Moving work content throughout the build process requires the help of engineers and operators. The kaizen champion should have some expertise of the product design when balancing by work content. Although the kaizen event has not started, the kaizen champion can simply ask the operators about changes in the work order. Once the kaizen event starts, team members can analyze the work content making sure nothing unusual has been done. For instance, a wire harness cover cannot be installed before the wire harness. The work content balance is shown in Figure 7.16 through 7.20.

Since workstation 1, 2, and 3 balanced out very well during the time balance, the work content balance can start at workstation 4.

Workstation 4 needs more adjusting to help balance out the assembly process. Fortunately, sequence 210, install and connect wire harness, in workstation 5 can be separated into two steps. If 1.85 min of it can moved into workstation 4 from workstation 5, then the cycle time in workstation 4 becomes 4.52 min, placing it much closer to a takt time of 4.84 min. By doing this, the cycle time in workstation 5 dropped significantly.

To bring workstation 5 closer to takt time, look at the work content in workstation 6 to see what can be moved. Sequences 230, 240, 250, and 260 equal 1.67 min of work, so remove them from the beginning of workstation 6 and place them at the end of workstation 5. This is an ideal situation when line balancing. If work can be moved from one station to the next without changes in the original build sequence, less training will have to be done for the operators. Operators can get used to a certain way of working, and severe changes to their old pattern will cause confusion. However, if the build sequence has to be severely altered to improve flow and productivity, then it has to be done. It just creates a steeper learning curve during the training phase.

Workstation 1		
Seq #	**Work Content**	**Time**
10	Install Frame to Shipping Pallet	3.17
20	Install (2) Shock Absorbers to Front Forks	0.25
30	Install Front Forks to Frame	0.82
40	Install Front Wheel to Front Forks	0.36
	Total	**4.60**

Workstation 2		
Seq #	**Work Content**	**Time**
50	Install (4) Black Rubber Bumpers to Frame	0.26
60	Install Battery Pack into Center of Frame	0.60
70	Install Serial Number Label to Frame	0.15
80	Connect Electric Motor to Voltage Tester	0.56
90	Test Electric Motor	1.25
100	Place Operator I.D. Label on Electric Motor	0.18
110	Remove Electric Motor from Voltage Tester	0.55
120	Install Electric Motor to Frame	0.66
	Total	**4.21**

Workstation 3		
Seq #	**Work Content**	**Time**
130	Install Fuse Box to Frame	0.56
140	Install Horn to Frame	0.27
150	Install Drive Chain to Electric Motor	0.16
160	Install Rear Wheel Assembly and Wrap Drive Chain around Sprocket	0.92
170	Route Brake Cable from Rear Wheel and Secure	1.21
180	Route Throttle Cable from Rear Wheel and Secure	1.21
	Total	**4.33**

FIGURE 7.16
Workstations 1 through 3.

Workstation 4		
Seq #	**Work Content**	**Time**
190	Secure Rear Wheel Assembly	1.94
200	Attach Brake Cable to Brake Drum and Adjust Tension	0.73
205	Install and Connect Wire Harness Wires	1.85
	Total	**4.52**

Workstation 5		
Seq #	**Work Content**	**Time**
210	Install and Connect Wire Harness	1.75
220	Secure Wire Harness Wires	1.31
230	Install Main Body Panel S/A	1.04
240	Install Black Grommet on Back Suspension	0.15
250	Install (2) 1" Lock Nuts Over Black Grommet	0.33
260	Install Black Grommet on Front Forks	0.15
	Total	**4.73**

FIGURE 7.17
Workstations 4 and 5.

The same situation occurs in workstations 6, 7, 8, and 9 (See Figure 7.18). Work content can be removed from workstations downstream to stations upstream. Sequences 350, 360, and 370 can be taken from workstation 7 and placed in workstation 6.

Sequences 420, 430, and 440 can be removed from workstation 8 and placed in workstation 7, and sequence 510 from workstation 9 can be moved and used to balance workstation 8 to 4.13 min.

As you can see, workstation 9 is already close to takt time. After balancing the first nine workstations, workstation 9 has become a dedicated test operation. It is perfectly safe to have non-test work performed at a test station to keep the product flowing to takt time.

The run test performed in sequence 530 is external work. External work is activity that can be done that does require operator involvement. The run test in this case is conducted by turning on the testing machine and letting it perform the diagnostic on its own. The operator can then conduct the product inspection procedure while the electric bike is being tested. The kaizen team will have to pay attention to the workstation design during the kaizen event to allow the operator to do these tasks without disrupting takt time.

Workstation 10 is the packaging operation. Removing the nonvalue-added work content in sequence 730 will balance the workstation to 4.80 min. If the operator is no longer required to leave the workstation and move the final product to shipping, he or she can be in the workstation all the time.

Workstation 6		
Seq #	**Work Content**	**Time**
270	Install (2) 1" Lock Nuts Over Black Grommet	0.33
280	Install Seat Post to Main Body Frame	0.15
290	Install Seat Cushion to Post	0.63
300	Install Seat Quick Release S/A	0.23
310	Install Center Panel Lock To Center Panel	0.32
320	Install Center Panel to Main Body Panel	0.22
330	Install Handle Bar Frame	0.60
340	Install Quick Release S/A and Secure	0.24
350	Install Rubber Cover on Quick Release S/A	0.54
360	Install Protective Rubber to Seat Post	0.74
370	Install Headlight S/A onto Handle Bar Frame	0.37
	Total	**4.37**

Workstation 7		
Seq #	**Work Content**	**Time**
380	Route Wire Harness Up Handle Bar Frame and Secure	1.76
390	Install Black Conduit around Wires	0.35
400	Install Ignition to Ignition Cover	0.59
410	Install Back Harness Cover to Front Harness Cover	0.38
420	Install Ignition Cover to Front Harness Cover	0.48
430	Install Brand Label to Plastic cover	0.13
440	Connect LCD Circuit Board to LCD	0.73
	Total	**4.42**

Workstation 8		
Seq #	**Work Content**	**Time**
450	Install the Back Console Panel to the Headlight S/A	0.48
460	Connect Throttle Cable to Throttle Handle S/A	0.26
470	Insert Throttle Handle to Handle Bar Frame and Secure	0.39
480	Connect Brake Cable to Adjustable Handle S/A	0.26
490	Insert Adjustable Handle to Handle Bar Frame and Secure	0.38
500	Install Trunk Brace	1.12
510	Install Trunk S/A to Trunk Brace	1.24
	Total	**4.13**

FIGURE 7.18
Workstations 6, 7, 8, and 9. *Continued.*

Workstation 9		
Seq #	**Work Content**	**Time**
520	Connect Bike to Testing Machine	0.56
530	Perform Run Test and Inspection	2.01
540	Fill out Run Test Form	1.03
550	Disconnect Bike from Testing Machine	0.57
560	Place Operator I.D. Label on Electric Motor	0.18
570	Inflate Tires	0.34
580	Place Bike Helmet on Pallet	0.18
	Total	**4.87**

FIGURE 7.18
Continued.

Workstation 10		
Seq #	**Work Content**	**Time**
590	Place Mirror on Pallet	0.18
600	Secure Tool Kit S/A to Frame	0.32
610	Place Instruction Kit S/A on Pallet	0.17
620	Place Battery Charger in Poly Bag	0.12
630	Place Battery Charger on Pallet	0.17
640	Install (2) Blue Box Holder to Shipping Box	0.36
650	Fold Shipping Box	0.31
660	Place Shipping Box over Shipping Pallet	0.19
670	Staple the Shipping Box to the Shipping Pallet	0.72
680	Place Foam Wrap Over Electric Bike and Secure with Tape	0.11
690	Fold Top Box	0.18
700	Staple Top Box to Shipping Box	0.24
710	Install Banding Around Shipping Box	1.49
720	Install Packaging Tape over Banding	0.24
	Total	**4.80**

730	*Move Finished Product to Shipping Area*	*1.20*

FIGURE 7.19
Workstation 10.

Head Light Station 1		
Seq #	**Work Content**	**Time**
10	Install Left Hand Side Signal Reflector to Headlight Panel	0.55
20	Install Headlight Reflector to Headlight Panel	0.54
30	Install Right Hand Side Signal Reflector to Headlight Panel	0.55
40	Install (2) Signal Bulbs to Light Module	0.17
50	Install (1) Headlight Bulb to Light Module	0.08
60	Install Light Module to Headlight Panel	0.31
65	Connect Headlight Wire Harness to Light Module	2.20
	Total	**4.40**

Head Light Station 2		
Seq #	**Work Content**	**Time**
70	Connect Headlight Wire Harness to Light Module	4.20
	Total	**4.20**

Head Light Station 3		
Seq #	**Work Content**	**Time**
80	Secure Wires	3.28
	Total	**3.28**

FIGURE 7.20
Headlight workstations.

The forklift drivers from the shipping department can take the finished product from the assembly line and place it in shipping.

Workstation 2 of the headlight subassembly is over takt time. Similar to workstations 4 and 5 on the main assembly line, split up the assembly work required to install the wire harness. This will balance out the first two workstations to 4.40 and 4.20 min, respectively. However, workstation 3 is at 3.28 min. There will be situations in the line balancing exercise when the workstation requirements do allow for perfect balance to takt time. In this case, the assembler in workstation 3 will have some time to wait. If there is no other work content that can be added to this workstation, add some additional quality checks to ensure that the headlight is made to specifications (see Figure 7.20).

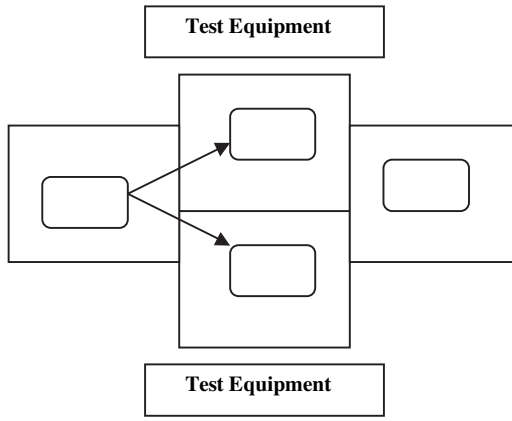


FIGURE 7.21
Added test stations.

Balance by Material

Except for the subassemblies that do not require workstation balancing, the assembly process is set to takt time. There will be some occasions when more line balancing is needed to flow the assembly process. The last line balancing rule is to balance by material or inventory.

A perfect example is a test workstation. Sometimes the test requirements can exceed well beyond takt time. A test engineer or technician can sometimes refine the test process so it can be completed in the established takt time. If they are unsuccessful, a good remedy to the problem is to design the workstation to accommodate two units at the same time. Figure 7.21 illustrates this idea.

By doing this, you are adding WIP to the assembly line. Of course this is not single piece flow, but it may be required to keep the assembly line moving as needed. For example, if the cycle time for testing is 9.68 min, then the line will still move close to 4.84 min. The work content is external, so both units can be tested at the same time. However, this is never an exact science since the testing procedure will not always end at exactly 4.84 min every time. It simply ensures that this workstation will not create a bottleneck and that the kaizen team does not have to physically build another workstation.

The other aspect of material balancing is to analyze the size of the parts that will be placed into the workstation for assembly. I have designed assembly lines where the material was so large that the workstations were quite long. Material should never be placed any further than arms length or stacked back to back so the operator has to walk around pallets and totes. This will inherently add time to the workstation and slow the process down.

Make sure that this element of line balancing is looked at prior to the kaizen event. The use of CAD (computer assisted drawing) software can provide a nice visual aid to identify this type of problem.

Balancing an assembly line requires attention to detail. It is important to follow the line balancing rules and make sure that no workstation is above takt time. Utilizing subassembly feeders can help in loading all main line workstations to takt time as long as the feeder line is set to the same takt time. Takt time is the goal of any line balancing exercise. Once you can load all the workstations just under takt time, you can move on to assembly line design and prepare for the kaizen event.

Chapter Summary

- Select the team members.
- Get an update on supplies and equipment that were ordered and external resources that have been reserved.
- The team members should start interacting with the operators on the line that has been selected.
- Balance the assembly line using the time and motion studies.
- Calculate takt time: electric bike line = 4.84 min.
- Calculate the workstation requirements.
- The electric bike line workstations include ten main line stations, three headlight feeder stations, and one subassembly work cell using two operators.
- Use the four line balancing rules.
- Make sure all workstations are below takt time.

8

One Week to Go

The week before the event should be used to make final preparations for the kaizen team. Figure 8.1 shows the one-week checklist; a checklist of the items that must be completed by the end of the week. The kaizen champion and the team leader should work together to ensure that everything is ready for next week's event.

Gather Current State Statistics

Current conditions should be documented, as they will be compared to the final results, and used to formulate the financial achievements of the kaizen event. The following information should be gathered:

- Number of workstations
- Number of operators
- Floor space (ft^2)
- Length of the assembly line
- WIP (units, not parts)
- Current volume
- Scrap and rework information
- Year-to-date productivity
- Process design efficiency

Meet with the Team Members

Towards the end of the week, the team leader and kaizen champion should hold a short meeting with the team, briefing them on the kaizen event. Most of the information provided in this meeting has either been posted on the

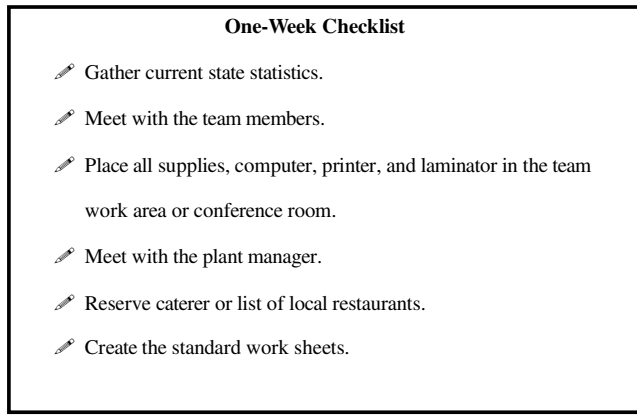


FIGURE 8.1
One-week checklist.

kaizen event communication board, or has been communicated verbally. The team should be given the kaizen event week schedule (tentative), the hours to be worked, a listing of the anticipated results, food preparations, work or conference room details, attendance policies, training materials, and the reasons why each team member was selected.

Miscellaneous Preparations

The kaizen champion should place the kaizen event supply box in the work area and collect any supplies that the team will require including pens, markers, paper, computer, printer, laminator, tape, scissors, safety glasses, and notebooks. It is also good practice for the team leader, kaizen champion, and plant manager to meet briefly and review the goals for the event. Additionally, the team leader should ensure that he now has access to any funds that were budgeted for the event.

Lunch coverage should be verified. If the company is going to hire a catering company to bring food and beverages, the team leader needs to confirm with the caterer. If a caterer will not be used, a list of local restaurants should be prepared and made available to the team.

Standard Work Sheets

With one week left until the kaizen event, the kaizen champion and team leader should create the standard work sheets for the assembly line. This is

a significant moment in the design phase; a mountain of documentation is reduced to just a few pieces of paper.

Standard work sheets show all the necessary elements of each workstation, as well as the design requirements. Each standard work sheet will consist of one piece of paper, outlining everything needed to set up the workstation to operate at 4.84 min. Using the final line balancing sheets for each workstation, you can then identify the other important attributes of the standard work sheets.

The standard work sheets should include:

Station number
Sequence number
Work content
Cycle time
Part numbers
Part descriptions
Part quantity
Tool and equipment
Tool and equipment quantities
Tool sequence number

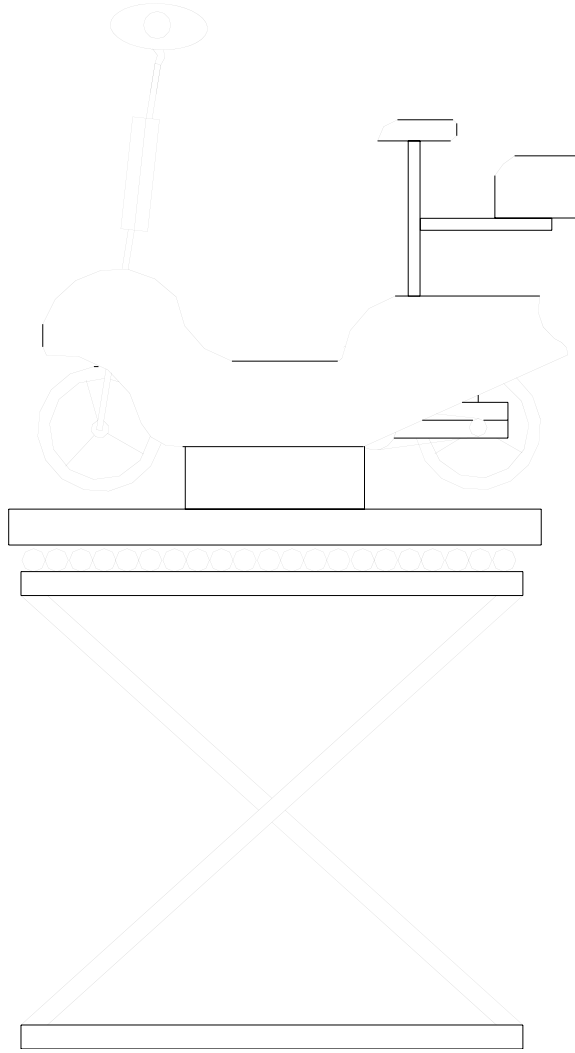
The kaizen team will use the standard work sheets as guidelines when designing the workstations. Standard work sheets should not be confused with work instructions. Although most of the information will also be included in the work instructions, the standard work sheets are essentially the blueprints for design.

Each sequence number has corresponding work content and time. The time that has been assigned to each work element should be considered the standard for performing the work.

Each standard work sheet will contain valuable material information. Every part that is required to perform the work should be listed. The quantity column represents how many of each part is needed for one unit every 4.84 min. This parts list allows the kaizen team to effectively construct material storage at the workstation, to ensure all parts are at point of use.

Finally, the standard work sheets contain tool and equipment information. Each tool is identified by one or more sequence numbers, which are used to make a connection between the perspective work and the appropriate tool to perform the job. All of the workstations will utilize a rotating lift table, except for workstation 9. The height of each assembler will not be a concern as the lift tables will be used to position the bike at any level comfortable for the operator. Finally, during construction, the standard worksheets will be a valuable tool for the maintenance personnel on the team who will be connecting power and air lines. The standard work sheets for the main assembly line are shown in Figure 8.2 through Figure 8.10.

Main Assembly



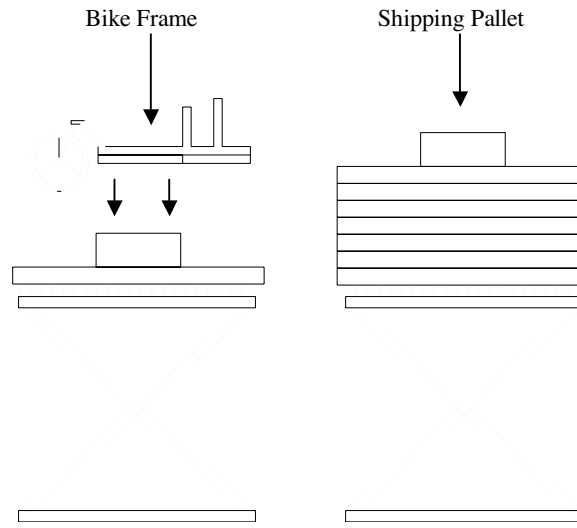
Workstation 1		
Sequence	**Work Content**	**Time**
10	Install Frame to Shipping Pallet	3.17
20	Install (2) Shock Absorbers to Front Forks	0.25
30	Install Front Forks to Frame	0.82
40	Install Front Wheel to Front Forks	0.36
	Total	**4.60**

Material		
Part Number	**Part Description**	**Qty**
25-2541-05	Bike Frame	1
36-8794-11	Shipping Pallet	1
25-2687-07	Shock Absorbers	2
26-7898-58	Front Forks	1
36-5478-05	Front Wheel	1
10-8741-98	3/4" x 3" Bolts	4
10-5494-25	3/4" Nuts	6
10-7895-71	1-1/2" Lock Nut	1
10-3659-21	Retainer Ring	1
10-3758-81	Bearing	1

Tools and Equipment		
Sequence	**Description**	**Qty**
10 & 40	3/4" Air Drill	1
10	Ratchet	1
10	3/4" Socket	1
30	1/2" Wrench	1
-	Rotating Lift Table	1
10	Pallet Lift Table	1

FIGURE 8.2
Standard work for workstation 1.

The operator assigned to workstation 1 will be required to perform four operations, with the most challenging being the installation of the frame to the shipping pallet. This workstation will be equipped with a lift table to store the shipping pallets at waist level. Material handlers will place a designated quantity of pallets on the lift table and the operator will pull the shipping pallets to the workstation.



Workstation 2		
Sequence	**Work Content**	**Time**
50	Install (4) Black Rubber Bumpers to Frame	0.26
60	Install Battery Pack into Center of Frame	0.60
70	Install Serial Number Label to Frame	0.15
80	Connect Electric Motor to Voltage Tester	0.56
90	Test Electric Motor	1.25
100	Place Operator I.D. Label on Electric Motor	0.18
110	Remove Electric Motor from Voltage Tester	0.55
120	Install Electric Motor to Frame	0.66
	Total	**4.21**

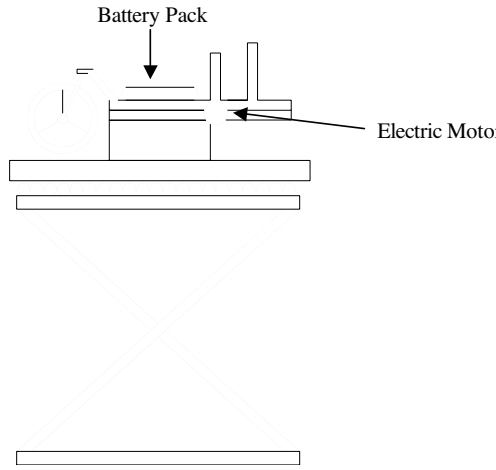
Material		
Part Number	**Part Description**	**Qty**
42-8547-95	Black Rubber Bumpers	4
42-7859-05	Battery Pack	1
48-3649-25	Serial Number Label	1
48-3650-26	Operator I.D. Label	1
51-0250-91	Electric Motor	1
10-5849-36	1/8" x 1" Bolts	4

Tools and Equipment		
Sequence	**Description**	**Qty**
120	1/8" Air Drill	1
100	Black Pen	1
80	Electric Motor Voltage Test Machine	1
80	Voltage Reader	1
-	Rotating Lift Table	1

FIGURE 8.3
Standard work for workstation 2.

The operator in workstation 2 will have assembly and testing responsibilities. After completing three operations, the operator will connect the electric motor to a voltage tester. Unfortunately, this work is nonvalue-added, but it is always a good practice to conduct part tests as early as possible. If the electric motor is tested farther downstream and it fails, multiple parts would need to be removed. If the motor fails at workstation 2, this issue can be resolved faster, without trickle-down effects.

After the motor passes its voltage test, the operator will place an operator identification label on the motor. The label tells other assemblers that the motor passed the test.

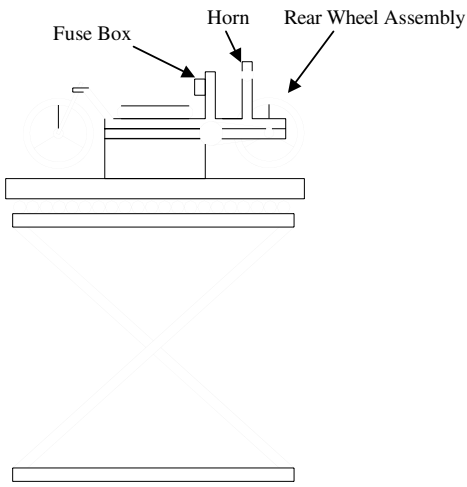


Workstation 3		
Sequence	**Work Content**	**Time**
130	Install Fuse Box to Frame	0.56
140	Install Horn to Frame	0.27
150	Install Drive Chain to Electric Motor	0.16
160	Install Rear Wheel Assembly and Wrap Drive Chain around Sprocket	0.92
170	Route Brake Cable from Rear Wheel and Secure	1.21
180	Route Throttle Cable from Rear Wheel and Secure	1.21
	Total	**4.33**

Material		
Part Number	**Part Description**	**Qty**
31-2568-02	Fuse Box	1
31-7490-90	Horn	1
32-6592-56	Drive Chain	1
25-9146-33	Rear Wheel Assembly	1
11-7978-99	Brake Cable	1
11-0584-23	Throttle Cable	1
10-0009-04	#8 Tek Screw	2
10-1958-68	1/8" Nut	1
12-2369-11	Black Tie Wraps	8

Tools and Equipment		
Sequence	**Description**	**Qty**
130 & 140	1/8" Air Drill	1
130	Phillip Drill Bit	1
170 & 180	Wire Cutters	1
-	Rotating Lift Table	1

FIGURE 8.4
Standard work for workstation 3.



Workstation 3 is one of the easier workstations. Most of the parts are small, and the operator is not required to do any testing. However, it is important that the brake cables in sequence 170 and the throttle cable in sequence 180 are secured properly using black tie wraps.

Workstation 4		
Sequence	**Work Content**	**Time**
190	Secure Rear Wheel Assembly	1.94
200	Attach Brake Cable to Brake Drum and Adjust Tension	0.73
205	Install and Connect Wire Harness Wires	1.85
	Total	**4.52**

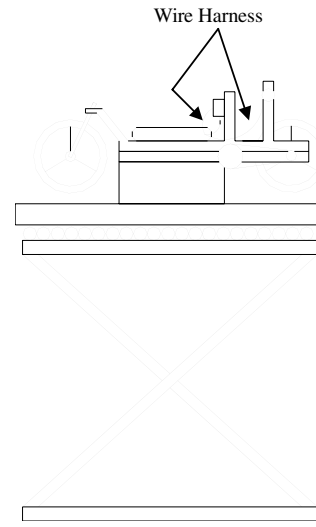
Material		
Part Number	**Part Description**	**Qty**
41-1247-25	Wire Harness	1

Tools and Equipment		
Sequence	**Description**	**Qty**
190 & 200	9/16" Torque Driver	1
190 & 200	Ratchet	1
190 & 200	9/16" Socket	1
-	Rotating Lift Table	1

FIGURE 8.5
Standard work for workstation 4.

The electric bike's main wire harness is installed at workstation 4. Remember, during the line balancing exercise, the wire harness installation was divided between workstation 4 and workstation 5 in order to enhance flow. The work instructions will have to be created in enough detail so that the assembler knows which wires are to be connected in each workstation.

Sequence 190 involves securing the rear wheel assembly. Workstation 3 simply installs the rear wheel assembly, but does not secure it. The rear wheel is heavy enough to sit on the frame without falling while moving to workstation 4.

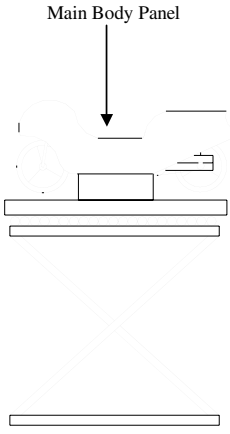


Workstation 5		
Sequence	**Work Content**	**Time**
210	Install and Connect Wire Harness	1.75
220	Secure Wire Harness Wires	1.31
230	Install Main Body Panel S/A	1.04
240	Install Black Grommet on Back Suspension	0.15
250	Install (2) 1" Lock Nuts Over Black Grommet	0.33
260	Install Black Grommet on Front Forks	0.15
	Total	**4.73**

Material		
Part Number	**Part Description**	**Qty**
12-2369-11	Black Tie Wraps	6
-	Main Body Panel S/A	1
21-3125-22	Black Grommet	2
10-5849-36	1/8" x 1" Bolts	4
10-1958-68	1/8" Nut	4
10-1114-80	1" Lock Nut	2

Tools and Equipment		
Sequence	**Description**	**Qty**
230	1/8" Air Drill	1
230	1/8" Socket	1
230	Air Ratchet	1
220	Wire Cutters	1
250	1" Wrench	1
-	Rotating Lift Table	1

FIGURE 8.6
Standard work for workstation 5.



There are two unique elements of work in workstation 5: The assembler will finish connecting the wires from the wire harness, and install the main body panel subassembly that will be built in a nearby work cell. Since the main body panel will cover the wire, it is important for the operator to make sure that no wires are hanging out.

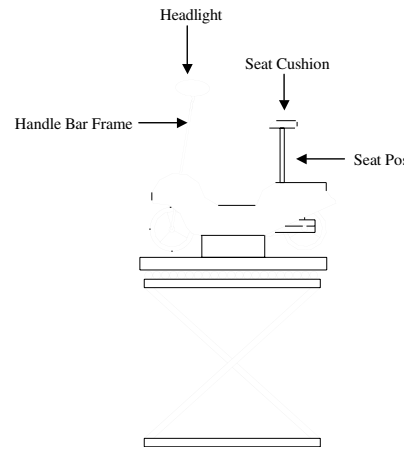
Workstation 6		
Sequence	**Work Content**	**Time**
270	Install (2) 1" Lock Nuts Over Black Grommet	0.33
280	Install Seat Post to Main Body Frame	0.15
290	Install Seat Cushion to Post	0.63
300	Install Seat Quick Release S/A	0.23
310	Install Center Panel Lock To Center Panel	0.32
320	Install Center Panel to Main Body Panel	0.22
330	Install Handle Bar Frame	0.60
340	Install Quick Release S/A and Secure	0.24
350	Install Rubber Cover on Quick Release S/A	0.54
360	Install Protective Rubber to Seat Post	0.74
370	Install Headlight S/A onto Handle Bar Frame	0.37
	Total	**4.37**

Material		
Part Number	**Part Description**	**Qty**
95-7421-56	Seat Post	1
85-9612-00	Seat Cushion	1
15-6578-95	Seat Quick Release S/A	1
14-7777-07	Center Panel Lock	1
15-6611-05	Handle Bar Frame	1
41-5475-66	Quick Release S/A	1
26-8967-26	Rubber Cover	1
26-8864-21	Protective Rubber	1
-	Headlight S/A	1
10-1114-80	1" Lock Nut	2
10-2265-77	9/16" Nut	2
10-5575-66	1/8" x 2" Phillip Screws	2

Tools and Equipment		
Sequence	**Description**	**Qty**
270	1" Wrench	1
340	9/16" Air Drill	1
370	Air Ratchet	1
370	Phillip Drill Bit	1
-	Rotating Lift Table	1

FIGURE 8.7
Standard work for workstation 6.

In workstation 6, a variety of assembly operations are performed, including the installation of the headlight subassembly. The headlight will be assembled on a feeder line that will be constructed perpendicular to workstation 6. Since the headlight feeder line will be designed to a takt time of 4.84 min, it will be presented to workstation 6 when it is needed.



Workstation 7		
Sequence	**Work Content**	**Time**
380	Route Wire Harness Up Handle Bar Frame and Secure	1.76
390	Install Black Conduit around Wires	0.35
400	Install Ignition to Ignition Cover	0.59
410	Install Back Harness Cover to Front Harness Cover	0.38
420	Install Ignition Cover to Front Harness Cover	0.48
430	Install Brand Label to Ignition Cover	0.13
440	Connect LCD Circuit Board to LCD	0.73
	Total	**4.42**

Material		
Part Number	**Part Description**	**Qty**
44-1144-05	Black Conduit	1
42-5670-00	Ignition	1
44-7895-33	Ignition Cover	1
25-8899-33	Back Harness Cover	1
25-8890-34	Front Harness Cover	1
09-7458-08	Brand Label	1
44-1862-36	LCD Circuit Board	1
44-5858-39	LCD	1
10-0009-04	#8 Tek Screws	2
10-0018-99	1/16" Phillip Screws	4

Tools and Equipment		
Sequence	**Description**	**Qty**
410, 440	Air Drill	1
410, 440	Phillip Drill Bit	
-	Rotating Lift Table	1

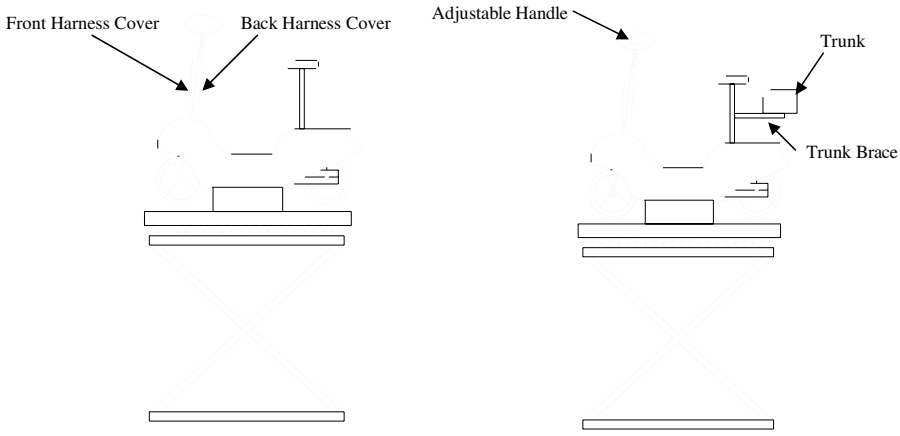
Workstation 8		
Sequence	**Work Content**	**Time**
450	Install the Back Console Panel to the Headlight S/A	0.48
460	Connect Throttle Cable to Throttle Handle S/A	0.26
470	Insert Throttle Handle to Handle Bar Frame and Secure	0.39
480	Connect Brake Cable to Adjustable Handle S/A	0.26
490	Insert Adjustable Handle to Handle Bar Frame and Secure	0.38
500	Install Trunk Brace	1.12
510	Install Trunk S/A to Trunk Brace	1.24
	Total	**4.13**

FIGURE 8.8
Standard work for workstations 7 and 8.

Material		
Part Number	**Part Description**	**Qty**
68-9711-01	Back Console Panel	1
-	Headlight S/A	1
68-1154-55	Throttle Handle S/A	1
68-2568-44	Adjustable Handle S/A	1
69-6990-01	Trunk Brace	1
-	Trunk S/A	1
10-1155-60	3/16" x 5/8" Phillip Screws	4
10-1256-91	1/2" Allen Bolt	2
10-8745-55	3/16" Nut	2
10-1958-68	1/8" Nut	4

Tools and Equipment		
Sequence	**Description**	**Qty**
510	1/8" Air Drill	1
500	3/16" Air Drill	1
470, 490	Allen Wrench	1
450	Ratchet	1
450	Phillip Drill Bit	1
-	Rotating Lift Table	1

FIGURE 8.8
Continued.



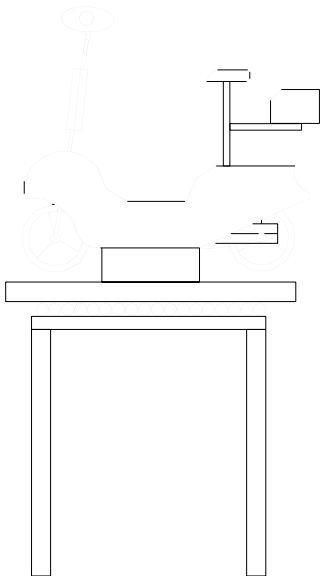
Workstations 7 and 8 will complete the last assembly operations prior to final run test and inspection. Workstation 8 will finish securing all the remaining wires and cables, before installing the trunk subassembly. The electric bike will be completely assembled after leaving workstation 8.

Workstation 9		
Sequence	**Work Content**	**Time**
520	Connect Bike to Testing Machine	0.56
530	Perform Run Test and Inspection	2.01
540	Fill out Run Test Form	1.03
550	Disconnect Bike from Testing Machine	0.57
560	Place Operator I.D. Label on Electric Motor	0.18
570	Inflate Tires	0.34
580	Place Bike Helmet on Pallet	0.18
	Total	**4.87**

Material		
Part Number	**Part Description**	**Qty**
08-7115-05	Run Test Form	1
48-3650-26	Operator I.D. Label	1
74-1256-98	Bike Helmet	1

Tools and Equipment		
Sequence	**Description**	**Qty**
520	Computer Monitor	1
520	Computer	1
530	Run Test Machine	1
570	Air Compressor	1
560	Black Pen	1
570	Tire Gauge	1

FIGURE 8.9
Standard work for workstation 9.



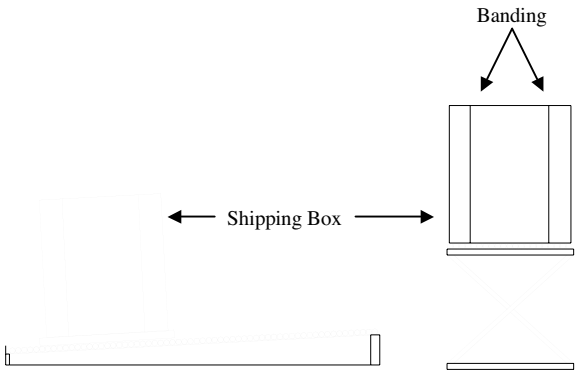
The electric bike will be connected to a testing machine, where it will undergo a series of diagnostics and inspections. The cycle time for workstation 9 is slightly higher than takt time. However, the testing operation of the workstation is external work. The operator will perform the other operations in the workstation while the bike is being tested. As you can see, workstation 9 will not require a rotating lift table. The electric bike is required to stay at one height for testing and inspection purposes. After the bike has passed its final run test and inspection, the operator will inflate the tires and place the bike helmet accessory on the pallet. At this point, the electric bike is ready to be prepped for shipping.

Station 10		
Sequence	**Work Content**	**Time**
590	Place Mirror on Pallet	0.18
600	Secure Tool Kit S/A to Frame	0.32
610	Place Instruction Kit S/A on Pallet	0.17
620	Place Battery Charger in Poly Bag	0.12
630	Place Battery Charger on Pallet	0.17
640	Install (2) Blue Box Holder to Shipping Box	0.36
650	Fold Shipping Box	0.31
660	Place Shipping Box over Shipping Pallet	0.19
670	Staple the Shipping Box to the Shipping Pallet	0.72
680	Place Foam Wrap Over Electric Bike and Secure with Tape	0.11
690	Fold Top Box	0.18
700	Staple Top Box to Shipping Box	0.24
710	Install Banding Around Shipping Box	1.49
720	Install Packaging Tape over Banding	0.24
	Total	**4.80**

Material		
Part Number	**Part Description**	**Qty**
13-1325-98	Mirror	1
-	Tool Kit S/A	1
-	Instruction Kit S/A	1
13-2548-74	Battery Charger	1
09-1144-15	Poly Bag	1
07-3696-33	Blue Box Holder	2
50-5540-50	Shipping Box	1
50-5541-50	Top Box	1
09-2215-00	Foam Wrap	1
10-0055-44	Staples	-
87-8895-64	Banding	-
87-8325-11	Packaging Tape	-

Tools and Equipment		
Sequence	**Description**	**Qty**
670, 700	Staple Gun	1
680	Scissors	1
710	Banding Gun	1
720	Tape Gun	1

FIGURE 8.10
Standard work for workstation 10.



The last workstation operator on the assembly line will install all the necessary packaging material and various accessories. The shipping box will be stapled and banded to the pallet, and a forklift will remove it from the assembly line.

Headlight Assembly

The headlight will be assembled on a three-station feeder line ending at workstation 6, where it will be installed on the bike. The majority of the work will be done at the first workstation because of the complexity of the wire harness. The standard work sheet for the headlight feeder line is shown in Figures 8.11 through 8.13.

Headlight 1		
Sequence	**Work Content**	**Time**
10	Install Left Hand Side Signal Reflector to Headlight Panel	0.55
20	Install Headlight Reflector to Headlight Panel	0.54
30	Install Right Hand Side Signal Reflector to Headlight Panel	0.55
40	Install (2) Signal Bulbs to Light Module	0.17
50	Install (1) Headlight Bulb to Light Module	0.08
60	Install Light Module to Headlight Panel	0.31
65	Connect Headlight Wire Harness to Light Module	2.20
	Total	**4.40**

Material		
Part Number	**Part Description**	**Qty**
77-4859-32	Left Hand Side Signal Reflector	1
44-1111-10	Headlight Panel	1
77-2591-02	Headlight Reflector	1
77-4510-56	Right Hand Side Reflector	1
44-2512-69	Signal Bulb	2
44-2513-71	Headlight Bulb	1
65-0000-15	Light Module	1
41-0023-41	Wire Harness	1
10-0025-66	3/16" x 1/2" Phillip Screws	3

Tools and Equipment		
Sequence	**Description**	**Qty**
60	3/16" Air Drill	

FIGURE 8.11
Standard work for headlight 1.

Headlight 2		
Sequence	**Work Content**	**Time**
70	Connect Headlight Wire Harness to Light Module	4.20
	Total	**4.20**

No Tools or Material Required

FIGURE 8.12
Standard work for headlight 2.

Headlight 3		
Sequence	**Work Content**	**Time**
80	Secure Wires	3.28
	Total	**3.28**

Material		
Part Number	**Part Description**	**Qty**
12-2369-11	Black Tie Wraps	4

Tools and Equipment		
Sequence	**Description**	**Qty**
80	Wire Cutters	1

FIGURE 8.13
Standard work for headlight 3.

The remaining subassemblies do not require an extensive amount of work. The mirror, tool kit, main body panel, trunk, and instruction kit will be built to queue levels, and assembled in a work cell that is close to the main assembly line. Material handlers should be used to deliver the subassemblies to the appropriate workstation. The standard work sheets for the subassembly work cell are shown in Figure 8.14 through Figure 8.18.

Mirror		
Sequence	**Work Content**	**Time**
10	Install Mirror Extension to Mirror	0.14
20	Install Black Grommet to Mirror Extension	0.17
30	Install (1) 7/16" Nut to Mirror Extension	0.14
40	Place Mirror in Poly Bag	0.18
	Total	**0.63**

Material		
Part Number	**Part Description**	**Qty**
12-0247-61	Mirror	1
25-0025-36	Mirror Extension	1
25-2525-12	Black Grommet	1
09-1144-15	Poly Bag	1
10-7192-38	7/16" Nut	1

Tools and Equipment		
Sequence	**Description**	**Qty**
30	7/16" Air Drill	1

FIGURE 8.14
Standard work for the mirror.

Tool Kit		
Sequence	**Work Content**	**Time**
10	Place 9/16" Wrench in Black Bag	0.13
20	Place Large Allen Wrench in Black Bag	0.14
30	Place Small Allen Wrench in Black Bag	0.13
40	Place Phillip Screw Driver in Black Bag	0.14
50	Place Standard Screw Driver in Black Bag	0.14
60	Place Hex Wrench in Black Bag	0.14
	Total	**0.82**

Material		
Part Number	**Part Description**	**Qty**
02-1496-78	9/16" Wrench	1
02-1521-00	Large Allen Wrench	1
02-9541-22	Small Allen Wrench	1
02-2270-09	Phillip Screw Driver	1
02-2356-79	Standard Screw Driver	1
02-1155-60	Black Bag	1

No Tool or Equipment Required

FIGURE 8.15
Standard work for the toolkit.

Main Body Panel		
Sequence	**Work Content**	**Time**
10	Install Warning Label to Main Body Panel	0.17
20	Install Fuse and Fuse Cap	0.17
30	Install Charging Adaptor	0.22
40	Install Brake Light	0.74
50	Install Left Hand Side Signal Light	0.63
60	Install Left Hand Side 500 Watt Label	0.17
70	Install Right Hand Side Signal Light	0.63
80	Install Right Hand Side 500 Watt Label	0.17
	Total	**2.88**

Material		
Part Number	**Part Description**	**Qty**
11-1125-23	Warning Label	1
68-6203-33	Main Body Panel	1
10-7891-04	Fuse	1
13-5694-77	Fuse Cap	1
10-1225-94	Charger Adaptor	1
41-4189-23	Brake Light	1
41-4277-24	Left Hand Signal Light	1
41-4722-34	Right Hand Signal Light	1
11-11254-36	500 Watt Label	2
10-8745-55	3/16" Nut	3

Tools and Equipment		
Sequence	**Description**	**Qty**
40, 50, 70	3/16" Air Drill	1

FIGURE 8.16
Standard work for the main body panel.

Instruction Kit		
Sequence	**Work Content**	**Time**
10	Place (2) 30 Amp Fuses in Poly Bag	0.13
20	Place a 5 Amp Fuse In Poly Bag	0.14
30	Place (3) Keys in Bag	0.13
40	Place (2) 1/8" x 1" Spacers in Poly Bag	0.14
50	Place Instruction Manual in Poly Bag	0.14
60	Place (2) 1/16" x 1/4" Phillip Screw in Poly Bag	0.14
70	Seal Poly Bag Shut	0.14
	Total	**0.96**

Material		
Part Number	**Part Description**	**Qty**
04-2121-99	30 Amp Fuse	2
09-1144-15	Poly Bag	1
09-9974-65	Key	3
10-1025-10	1/8" x 1" Spacer	2
00-0156-00	Instruction Manual	1
10-2361-08	1/16" x 1/4" Phillip Screw	2

FIGURE 8.17
Standard work for the instruction kit.

Trunk		
Sequence	**Work Content**	**Time**
10	Install Lock to Trunk Bottom	0.32
20	Install Red Reflector to Trunk Top	0.34
30	Install Lock Bracket to Trunk Top	0.31
40	Install Trunk Label to Trunk Top	0.13
50	Install Top Trunk to Bottom Trunk	0.97
	Total	**2.07**

Material		
Part Number	**Part Description**	**Qty**
16-9802-55	Lock	1
68-4931-25	Trunk Bottom	1
77-7785-52	Red Reflector	1
68-4930-26	Trunk Top	1
44-2266-94	Lock Bracket	1
11-0003-69	Trunk Label	1
10-8745-55	3/16" Nut	10

Tools and Equipment		
Sequence	**Description**	**Qty**
20, 30, 40, 50	3/16" Air Drill	1

FIGURE 8.18
Standard work for the trunk.

At this point, all the necessary preplanning has been completed, the team members are ready for the kaizen event, and time and motion studies and the standard work sheets are ready for review. You can end this week with the assurance that everything is ready for a successful kaizen event.

Chapter Summary

- Gather current state statistics.
- Meet with team members and the plant manager to go over the goals of the kaizen team.
- Place all the necessary supplies, tools, and equipment into the kaizen work area so they are available on the first day.
- Verify that food will be provided and that the caterer or a list of local restaurants is ready for the week.
- Create the standard work sheets.
- Standard work sheets are essentially a blueprint for design.
- Standard work sheets contain all the necessary work content, times, tools, equipment, and parts needed to perform the work and design the workstation.

The Kaizen Event – The Electric Bike Line

9

Day One

The big day has finally arrived. There will be a variety of activities going on simultaneously. To ensure success, the event should be conducted under certain guidelines that keep the team members focused and on task. Figure 9.1 lists the items that must be completed in order to meet the objectives of day one.

Kickoff Meeting

The team leader should start the kickoff meeting by introducing the team members to one another. More than likely, the team members will recognize each other, but that depends on the size of the company. Each team member should identify himself by title, indicating what area of the facility he works in. The team leader should spend about an hour discussing 5S, standard work, the seven wastes, and visual management. Orientation is needed to help team members have a better understanding of why kaizen is important. This training is needed so the team is aware of the tools and methods that will be used to meet the objectives of the event. Reviewing the tools is a good practice, and will be helpful even for those who have been through lean training prior to the event. A brief overview by the team leader gives everyone a fresh perspective on how to proceed.

Make sure the team understands any constraints that may exist relative to moving machines and changing the plant layout. The team will need to be smart in their approach, ensuring that operators can still perform their work while the event is occurring. Positive and cooperative teamwork will make the event enjoyable as well as productive.

After the introduction, the team leader should provide an overview of the kaizen event, and cite the team objectives they will be required to meet by the end of the week. The team leader should have the week's schedule completed and posted on a flip chart or a presentation board. The objectives for each day should be outlined. As mentioned in Chapter 2, it is better to plan the kaizen event to occur during nonproduction hours. Try to stagger

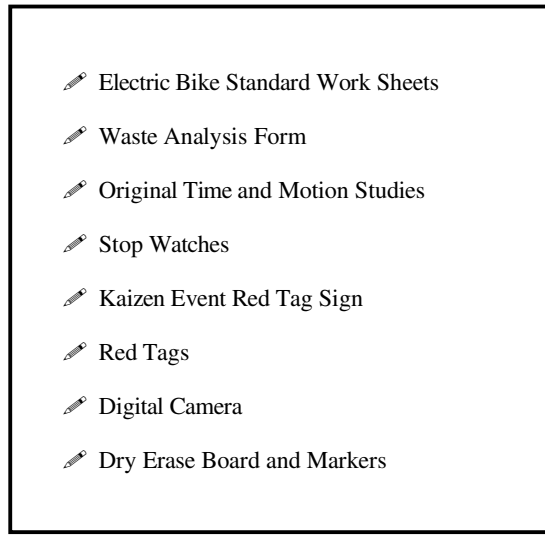


FIGURE 9.1
Day one necessities.

the start time, so the team begins working during the last few hours of the last shift, before the operators leave for the day. This allows the players to interact about various issues while the operators are still available. The schedule is only a general outline because activities during the event are subject to change. However, the schedule should be followed as closely as possible to ensure completion of the project (see Figure 9.2).

Ground Rules

Be on Time

All team members should be present when the event starts, during meetings, and at the end of the day. Since team members were selected two weeks prior to the event, there should be no excuses for absenteeism.

No Cell Phones or Pagers

There should be no disruption due to ringing phones and beeping pagers. Team members should provide friends and family with an office phone number or another front office number, rather than their direct line or cell phone number. The kaizen event is only for one week, so I don't believe this will be difficult to manage.

Event Schedule

Monday

Kick off meeting
Kaizen event overview
Allocate tools and supplies
Objectives and assignments
Current state pictures
Review standard work sheets of the electric bike line
Conduct the first "S" Sort, through a red tag event
Lunch
Midday meeting
Close out meeting

Tuesday (Line Construction)

Kick off meeting
Allocate tools and supplies
Objectives and assignments
Conduct the second and third "S": straighten and scrub of workstations
Lunch
Midday meeting
Close out meeting

Wednesday (Line Construction)

Kick off meeting
Allocate tools and supplies
Objectives and assignments
Continue the second and third "S": straighten and scrub of workstations
Monitor the assembly line and operators
Lunch
Midday meeting
Close out meeting

Thursday

Kick off Meeting
Allocate tools and supplies
Objectives and assignments
Set up visual management
Monitor the assembly line and operators
Prepare for Friday's close presentation
Lunch
Midday meeting
Close out meeting

Friday
Close out presentation

FIGURE 9.2
Kaizen event schedule.

100% Dedication of the Team

Team members' usual day-to-day responsibilities will be diverted to someone else in the facility. The kaizen governing committee has cleared all team members for 100% focus on the kaizen event. The team leader should be consulted immediately if any team member is approached to do something other than kaizen event activities.

Eat Lunch as a Team

Lunch should be provided for all team members. It is a privilege and an honor to be selected for a kaizen event and food should be made available for the team. The team leader will set a time for the lunch break and have lunch ready at that time. The team should sit together and relax during this lunch break.

Stay Positive

Kaizen events can be very stressful and things may go wrong that will throw team members off track. Work as a team and stay positive. Remember, the end result of the team's effort will be great, so push through the obstacles and get it done.

Make Decisions and Stay on Schedule

A majority of the preplanning has been done. All the equipment and supplies are ready for use. Time and motion studies have been completed and are ready for team review. Do not spend a huge amount of time planning and thinking during the event. Try to make decisions about a situation as quickly as possible, and then move on to the next item. Follow the schedule established by the kaizen team leader and work together to make results happen.

Let's Get to Work

The first day of the kaizen event involves two major activities. The first activity is to identify all unnecessary items in the old line by conducting a red tag event. The second activity is to review the standard work sheets that were prepared last week, searching for errors as well as improvement opportunities. Since the electric bike line consists of ten main line workstations and four small subassembly workstations, this team should consist of approximately ten to twelve members. Split the team into two teams with equal members to work on the two activities. The team leader should assign

the roles of each team member and their respective goals. Both teams should reconvene at a designated time for lunch and to give a brief status report.

Red Tag Team

Sorting does not necessarily mean throwing things away. The red tag campaign is a method of identifying potentially unnecessary items in the facility, assessing their need, and dealing with them effectively. A red tag campaign on day one helps to promote an organized method to the sorting efforts. Many items will be identified for reuse in future events. Sorting creates a work environment where space, time, money, and resources can be utilized in a more efficient manner. It allows for better visibility on the production floor, as well as better communication between operators and support staff.

Select an area in the plant where you can place tools, workbenches, jigs, dies, rejects, parts, and any other items that are no longer used. This will be the red tag area. Tape off the area with red tape, and post a sign indicating the area is for the red tag team (see Figure 9.3). This area is off limits to everyone in the plant except for the kaizen team.

Sometimes it is difficult to decide what needs to be removed from the work area. Use the standard work sheets as a guide because only the bare essentials are listed on the sheets. During workstation construction, maintenance may

FIGURE 9.3
Red tag sign.

install items and equipment that are not on the standard work sheets, and that is all right. These sheets simply outline the necessary items for assembly and basic workstation design. In the past, my general rule of thumb has been to have the teams remove any item in the area that has not been used for at least 30 days.

The team leader should give the red tag team a box of red tags that they will use to identify items for removal. I must admit that I have seen successful kaizen events where this activity was conducted without red tags. However, once the kaizen event was complete, it was difficult to evaluate the items and decide what should be done with them. A red tag event simply organizes the sorting activity in a more productive manner; the use of red tags makes the process even more efficient. Figure 9.4 shows a typical red tag used during red tag events.

During the red tag campaign, operators will challenge the removal of certain items. Team members must listen to all concerns, and ask for validation regarding how the disputed item is currently used. If the operator is unable to validate the use of an item, a red tag should be placed on it. Challenges should be rare, because every kaizen team includes two operators from the target assembly area, making identification of unnecessary items easier and less stressful.

The removal of work in process (WIP) during the first day can cause conflict. Therefore, although WIP is nonvalue-added, allow the operators to work through the WIP during day one of the event. Day two and day three of the weeks are good times to pull WIP out of the line. It can be filtered back through during the implementation of single piece flow.

The red tag team should spend the first half of the day placing red tags on unnecessary items. During the lunch break, they should report on their activities and results.

Review of the Standard Work Sheets

Once the red tag team has been released to the production floor, the team leader should give the standard work sheets to the remaining team members, who will act as the review team. Again, including an operator from the line will be very valuable when sifting through the information, as they may find errors that can be resolved prior to assembly line construction. The review team should identify opportunities for waste reduction and mistakeproofing. Make sure to have the original time and motion study data available. The kaizen champion should have removed a lot of the walking data, assuming that the parts and subassemblies will be placed at point of use. Also, the packaging removal operations have been moved to the receiving area so that work content will not be included in the design.

Organize the standard work sheets in order, from workstation 1 to workstation 10, and place them on the table. The headlight standard work sheets should be placed next to workstation 6 on the main assembly line. This

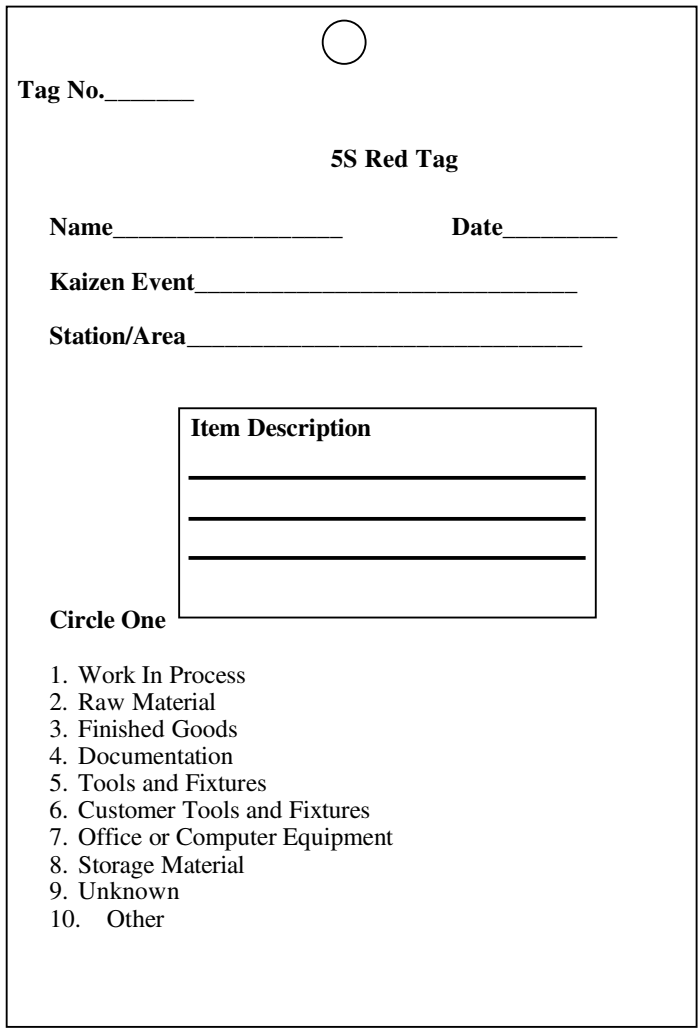


FIGURE 9.4
Red tag.

"straw man" exercise provides a nice visual representation of the assembly line. The review team should evaluate every sheet from start to finish.

Part of the review process is to go to the assembly line and verify the work content and the time studies. This is also a good time for a few members of the review team to go out onto the floor and identify and document non-value-added work on the waste analysis form. They can also use the old time and motion data to direct them towards areas of waste. This exercise is good for verifying the accuracy of the standard work sheets. The review team should randomly select a few operators and use stop watches to time their work. This will be the final check of the data, and any changes to the

standard work sheets should be done during this time. The review team should spend the first half of the day looking over the standard work sheets and analyzing the assembly line.

The team leader should leave the two teams alone, allowing them to work on their assignments independently, without supervision. During this time, the team leader can take current state photos of the assembly line, which will be used at the closeout presentation.

Lunch Break

The kaizen team should return to the break out room at the appointed lunch time and quickly discuss their work. Did the red tag team successfully red tag the items to be removed? Has the review team revised and updated the final draft of the standard work sheets? The team leader should write the results of each team on the board. The team should then relax and have lunch. The rest of the activities can be discussed after lunch.

Midday Meeting

After lunch, the team should refocus on the kaizen event. The team leader should conduct a midday meeting to go over the work completed prior to lunch, and to make assignments for the second half of the day. The standard work sheets should be verified and complete. The entire team should now work together to remove the red tagged items in the assembly line.

Completing the Red Tag Event

There will be large items, such as workbenches and equipment, which need to be removed. Maintenance personnel on the kaizen team should make sure that equipment is properly disconnected and hanging wires and cords are safely secured.

The team needs to move quickly, pulling the red tag items away before operators remove the tags. Remember, people become accustomed to working in waste because it creates a buffer for the inefficiencies, so be sure to work quickly and efficiently at this task.

The red tag area will fill up quickly. Two team members should be assigned to the area to monitor items as they come in, and verify that the red tags

have been properly filled out. These two people can help organize and maintain order, so that items do not just pile up.

During the red tag removal phase, the members of the kaizen governing committee and upper management should be invited to see the mountain of waste that has accumulated. The team leader should take photos to the red tag area for the closeout presentation, which will occur on Friday.

Eliminating unnecessary items through the red tag campaign will open up a tremendous amount of space. Future assembly lines can be installed in this newly found floor space. As red tagged items disappear from the assembly line, little islands of workbenches and equipment will start appearing. They represent the maximum number of items needed to work. The team members should compare this to the standard work sheets and verify the content.

By the end of the first day, the kaizen team should have successfully completed the red tag event and finalized the standard work sheets.

The following day, the operators may be a little confused or stressed. Just remember, each event is thoroughly planned four weeks in advance, and the production supervisors and operators are aware that there will be some added stress during the event. It is expected, and normal.

End of Day Meeting

The first day should conclude with an overview of the day's results and a plan of action for the second day. The team leader should leave information for the production manager, outlining what has been done to his or her work area.

Chapter Summary

- The kaizen event should start with a kickoff meeting.
- Good teamwork behavior will make the event more enjoyable for everyone.
- The team leader should post a schedule for the whole week.
- Action items and those responsible are posted in the break out room.
- Conduct a red tag campaign to remove all unnecessary items.
- Identify an area in the plant to put the items from the red tag campaign and place a sign there declaring it off limits.
- Review the standard work sheets and verify that the data is accurate.
- At the end of the first day, invite the members of the kaizen governing committee to see all the items removed from the area.

10

Day Two and Day Three

The team should begin day two and day three in the break out room, at the time specified by the team leader. Day two is the first day of laying out the new line. The team will conduct the second and third Ss of the 5S program: straightening and scrubbing. Maintenance projects should also begin on day two. A list of items needed for days two and three is shown in Figure 10.1. The first assignment of day two is to review the standard work sheets and come up with at least two line design ideas. Depending on how big and complex the line is, it can be good to have these design ideas before the event. I have even conducted line design kaizen events to make sure that the implementation team had everything they needed for construction. However, typically, there is plenty of time during the implementation event to come up with line designs that will work. Just use your best judgment when making this decision.

Line Design

Depending on floor space restrictions, the kaizen team should draw up at least two line designs. U-shaped cells are very effective for assembling small and simple products. Operators are usually positioned in the middle of the cell, working together to build a product. U-shaped cells allow the operators to see everything and help each other if necessary. The cell acts as one autonomous team. The first and last operators in the cell stand back to back. Used to working as a team, U-shaped cell operators are generally more flexible and can easily shift from station to station.

However, not all assembly "lines" can be converted into U-shaped configurations. Product lines that are big and bulky may require physically bigger assembly workstations and more material storage, which would not allow operators to have close contact with each other. U-shaped work cells should not consist of more than eight workstations, and, in fact, eight stations can be too many. I have seen U-shaped cells that were quite large due to the size and quantity of parts in the cell. In these cells, the operators were not in

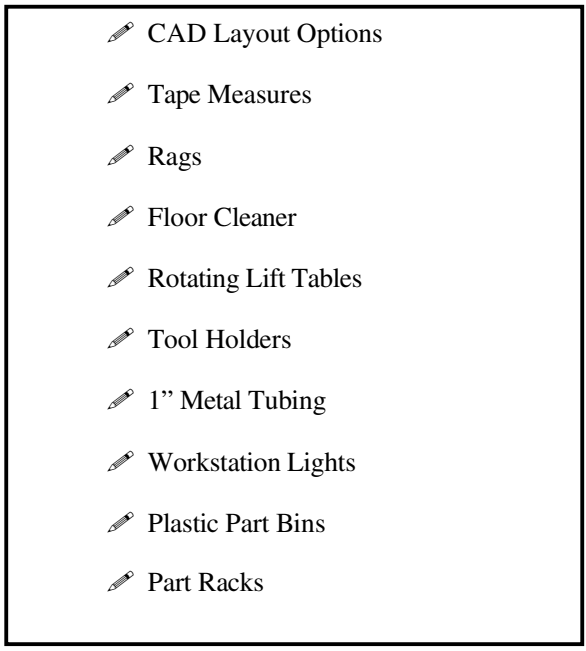


FIGURE 10.1
Days two and three necessities.

proximity, and had poor visibility, which defeats the purpose of building a cell team.

The challenge for the electric bike line is that there are a few large parts, as well as one feeder line that need to be accounted for. For the purposes of this book, and in regard to the electric bike line, we will use a traditional straight assembly line (see Figure 10.2).

Many successful lean assembly lines are exactly that: a straight line. U-shaped cells have become very popular over the years, but many manufacturers are able to operate very lean using straight line layouts.

Depending on the floor space and the constraints of other operations, it makes sense for the team to draw up the line design using CAD software. Make sure to include any expansion joints and retaining poles on the production floor. If your company does not have a plant layout, simply measure the area where the old line used to be, and stay within those boundaries. The red tag campaign from the previous day freed up a lot of floor space, so it should not be difficult to fit the new line layout into the area.

After discussing the preferred design, the team leader should assign the action items for the day. The assembly process needs to be pieced together into the shape of the new layout. The team leader should give each team member one or two standard work sheets, and members should go onto the floor and measure the items needed to construct the line. Parts racks, workbenches or lift tables, computer stands, pallets, bins, totes, garbage

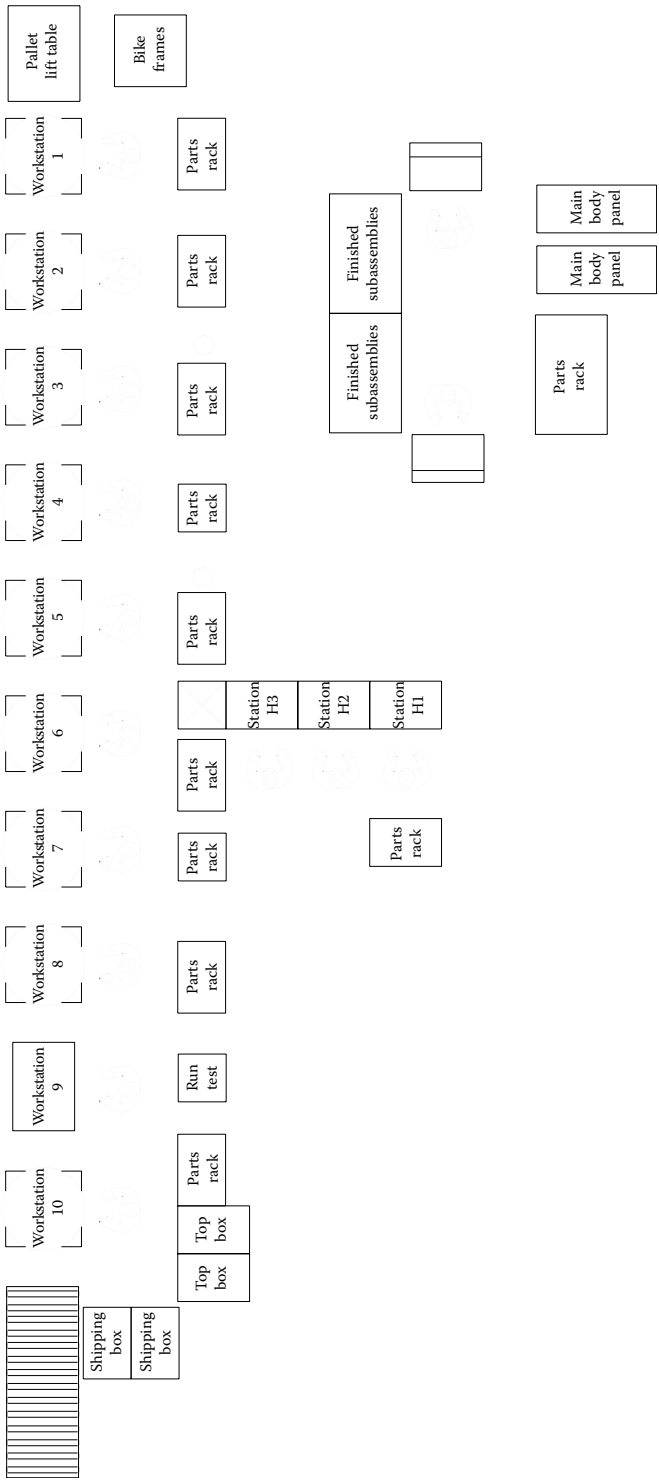


FIGURE 10.2
Straight line layout.

bins, and so forth. Again, the standard work sheet will outline everything that is necessary.

The team leader should assign a team member as a coordinator to monitor the measuring activities. As information is received from the team members, the team's drafter can begin drawing the line with the CAD software. The goal should be to have the measurements and line layout complete prior to lunch.

Midday Meeting

After lunch, the team should meet to discuss the action items for the second part of the day. Putting together the new line will take two days, using five stations per day as the average rule. The team has two objectives. First, they will construct the last five main line workstations and the three headlight workstations. Second, they will set up the workstations with the required parts and tools. The standard work sheets and the CAD layout are the only items necessary to complete the work.

Assembly Line Construction

Before the team begins construction of the assembly line, clean the floor to give it a show room shine. Many factory floors are painted, and I highly recommend painting, as it provides a great appearance. Painting a factory floor can be very expensive, but should be done at some point in the life of the factory. Do not attempt this during a kaizen event because the paint will not cure in time. Computer equipment, tools, fixtures, machinery, or any other mechanical objects should be cleaned, not only for appearance purposes, but for functional purposes as well. Workbenches, shelves, tables, and storage racks need to be clean and free of dust and debris.

Maintenance and Machine Shop Projects

The team needs to decide if there are any projects that the maintenance department should begin working on. Based on the information in the standard work sheets, the electric bike line will utilize rotating lift tables. Any new or existing equipment should be checked to ensure that it operates properly and is properly prepped for installation. Since the electric bike line will be using overhead tooling and lighting, a tool stand should be designed

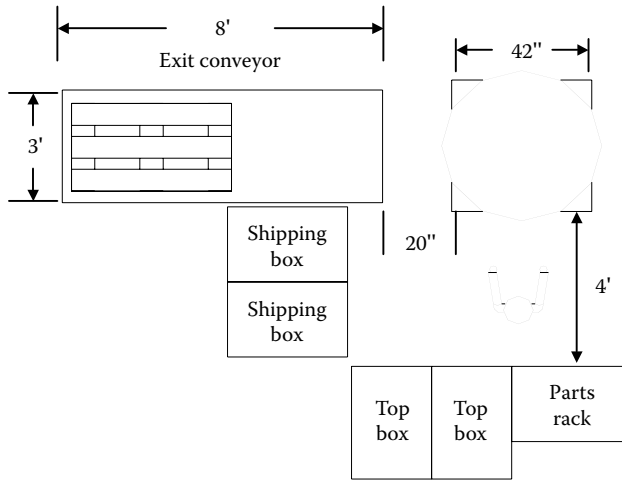


FIGURE 10.3
Top view of workstation 10.

and constructed. The electric bike line has ten workstations that will use these tool stands. If there are internal resource constraints, recontact one of the external resources that were contracted four weeks back to build the tool stands. Each tool stand will have a workstation light and tool holders. The team leaders should give the maintenance group the standard work sheets so they know how many tool holders are needed on each tool stand.

The assembly line should be pieced together starting from the last workstation. Find a starting point to measure for correct placement of the line. Expansion joints or retaining poles work well as reference points. Allow a distance of 4 ft from the workstation to any material storage. This will allow the assembler to turn easily and maneuver within the workstation. Let the material dictate how big the workstation area should be. Do not corner yourself in designing every workstation to the same dimensions. Some workstations could have large bulky parts and another could have small brackets and hardware. I will use workstation 10 as an example for the proper layout dimensions (see Figure 10.3).

The exit conveyor is 8 ft long and 3 ft wide. Once the bike is packaged and the operator in workstation 10 has finished, the unit will be placed on the exit conveyor. It will roll away from the assembly line to provide room for the forklift that will move it to the shipping area.

The exit conveyor and the workstation are 20 in. apart to allow the rotating lift table to rotate without bumping into the conveyor. The workstation is 42 in. in width and material should be placed at the required 4-ft distance. Figure 10.4 shows a side view of workstation 10.

The rotating lift table has a maximum height of 33 in. After completing his work, the operator can lower the table to 10 in., and the unit will roll down the exit conveyor.

FIGURE 10.4
Side view of workstation 10.

The team members should place all the required items in the last five workstations and the headlight feeder, and then remeasure the feeder's placement. It is important to make sure that everything is where it should be, based on the drawing. After the team has approved the layout, maintenance can begin securing the lift tables, the exit conveyor, and other pieces of equipment that need to be bolted to the floor. They can also drop the necessary air and electrical lines. Figure 10.5 shows the top view of the last five workstations and the headlight feeder line.

Notice that the workstations are evenly separated from one another and parts racks are placed at point of use. The headlight feeder line ends directly behind workstation 6. The finished headlight will be placed on the X at the end of the feeder. The operator in workstation 6 will retrieve the headlight and another one will be available in another 4.84 min.

The headlight feeder will not use rotating lift tables for assembly. Typically, 2×3 ft workbenches will work well in this case. With a good drawing and all team members participating, construction should go quickly.

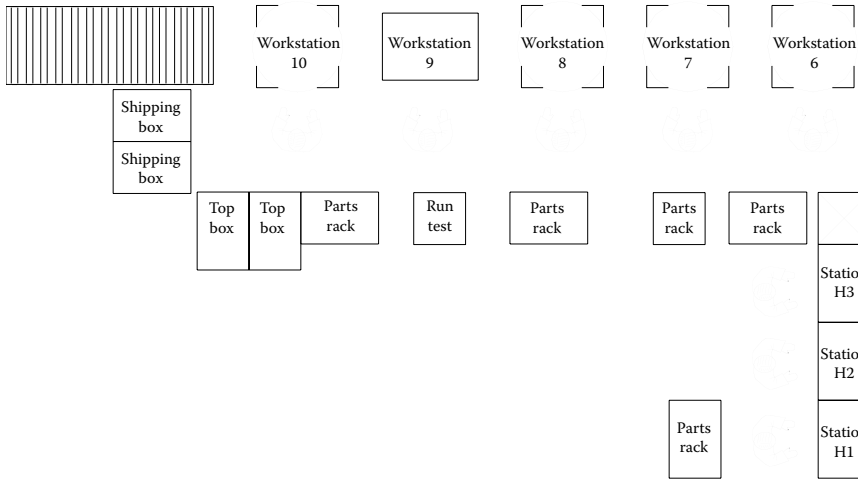


FIGURE 10.5
Top view of last five workstations.

Tool and Part Presentation

At this point, the area will still be a little cluttered. Excess parts left over from the old assembly line will be lying around, taking up unnecessary space on the new assembly line. Although the red tag campaign eliminated a majority of the tools, it is likely that part quantities are still too high. While maintenance secures the rotating lift tables, installs the computer, and runs test equipment, the team should head back to the break out room to discuss workstation design.

Divide the team into two groups. One group should work on tool presentation and the other on part presentation. Maintenance can start fabricating the tool stands and installing the tool holders.

Tools

Tools should be presented to the operator in a manner similar to parts. Never attach a tool to an operator; tools need to be attached to the workstation. The rotating lift table and the parts racks are both considered part of the workstation. The team needs to be creative when coming up with tool presentation ideas.

The ideal condition is when tools are positioned overhead, and at arm's length. This is good for small handheld air tools. Large tools will need more complex positioning. Tools that are not air powered, such as sockets, wrenches, wire cutters, and so forth, should also be at arms length, but not necessarily overhead. Since there are operators on the kaizen team, take the standard work sheets to the new workstations and formulate ideas for tool positioning. The operators are the best resource for this exercise.

There are a variety of options for tool presentation, and every workstation will be different, depending on the tool requirements. The two most common approaches to hanging overhead tools are tool balancers (see Figure 10.6) or retractors (see Figure 10.7).

Tool Balancers

Tool balancers are good for positioning hand tools overhead. Hand tools are connected to the balancers with small clips, and the operator can simply pull the tool down to do the work. Once the operator has completed his

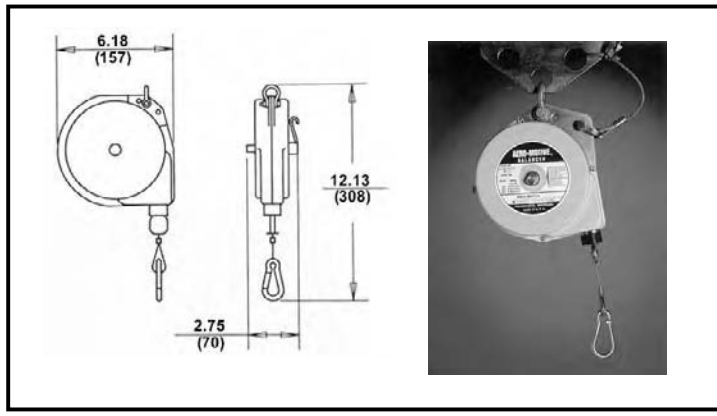


FIGURE 10.6
Tool balancer, courtesy of LK Goodwin Company, material handling equipment, Providence, RI.

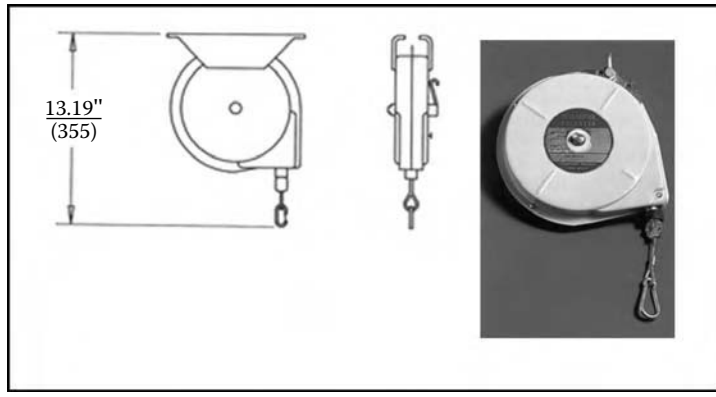


FIGURE 10.7
Tool retractor, courtesy of LK Goodwin Company, material handling equipment, Providence, RI.

work, the tool balancer will pull the tool back into the overhead position. However, there is one negative aspect to tool balancers. They tend to tug on the tool and sometimes the operator feels like he or she is fighting with it. Therefore, it is a good practice to use lightweight hand tools when utilizing tool balancers.

Tool retractors are a great alternative to balancers. They are very similar in regard to placement and function; however, they are designed to lock into position once the tool is pulled down. This enables the operator to maneuver around the product without fighting with the retractor. The operator then pulls down a little to unlock the retractor cord, and the tool rolls back into the static overhead position.

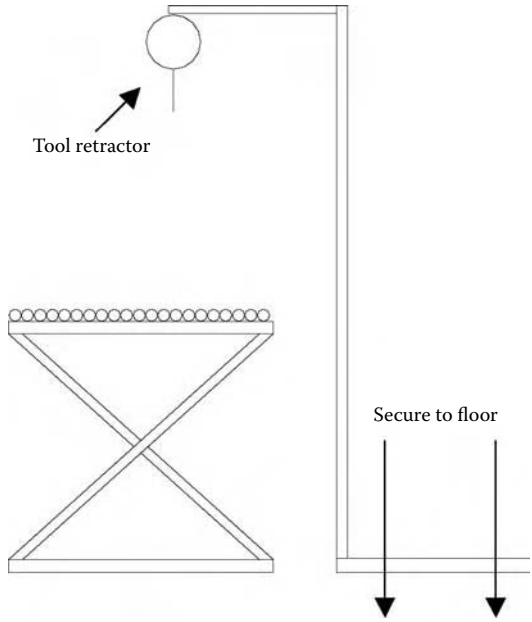


FIGURE 10.8
Tool stand.

Tool Stands

Overhead tools need to be secured either to the ceiling or the floor. Every plant has constraints when it comes to a ceiling installation, and there is no golden rule. You must do what is best for the assembly line. Figure 10.8 shows a tool stand that is installed in the floor over a rotating lift table.

Remember to provide sufficient clearance between the tool stand and the lift table to allow the unit on the lift table to rotate. Ceiling fixtures are the best option if you have limited floor space, but can require complex overhead construction. It could take days to construct ceiling fixtures for a ten-workstation assembly line. If ceiling fixtures already exist, I recommend using them during the kaizen event. However, the tool fixtures illustrated in Figure 10.8 are a good alternative.

Shadow Boards

Small tools and other devices needed for the assembly line may not be good candidates for overhead presentation. Shadow boards (see Figure 10.9), can

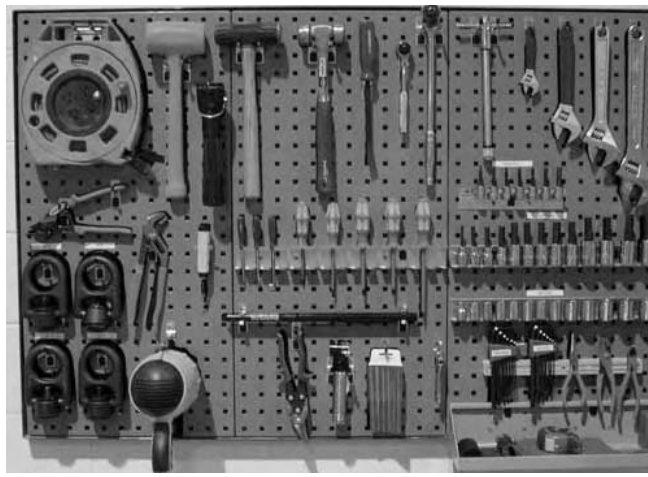


FIGURE 10.9
Shadow board.

be used to store tools in an organized fashion. They can be installed on the parts racks, next to the operator. This type of storage makes an absent tool very noticeable, when an audit is performed at the end of the day.

Parts

Part presentation at a workstation can have a positive or negative impact on flow and productivity. Poor presentation can create major bottlenecks in the assembly line and cause frustration and stress for the assembler.

During the planning phase, the kaizen champion organized the time and motion studies with the assumption that the kaizen team would present material and parts at point of use and in a "ready to go" state. Operators will not unpack or process parts. Operators must be able to pick and place parts into the bike without hesitation. Avoid placing hardware too close within the workstation. One type of screw, for example, could easily fall into a bin with screws of similar appearance, causing an operator to use the wrong screw accidentally. In order to avoid this problem, you should separate hardware through the parts rack when possible.

The parts team must decide on part quantities and the replenishment time for the workstations. Rather than get caught up in lengthy material replenishment calculations that involve various departments and individuals, the team can come up with suitable replenishment cycles independently. A very common and effective parts philosophy is the two-bin system. When followed and maintained, the two-bin system is extremely efficient.

The Two-Bin System

This concept is very simple. A part is stored in two identically sized containers, boxes, pallets, and so forth at the workstation. Operators work out of one of the containers until it becomes completely empty. The empty container signals the material handler to replenish the part. The operator can work out of the second container while the first one is being refilled. Both containers have the same quantity of parts and should be placed on top of one another. When the material handler returns to the workstation, he places the newly replenished container under the one the operator is currently using. To set up the two-bin system, the team needs to take into account the necessary components for part presentation, as follows:

Part use in containers
Large part use not in containers
Subassemblies

Part Use in Containers

The designed daily volume for the electric bike line is 72 units. The team needs to review the standard work sheets for the last five workstations and the headlight feeder in order to get an idea of how much material will be stored on the line. When selecting part quantities, the team has to consider space. High part quantities allow for less replenishment cycles, but may take up too much space. The assembly line is not a storeroom, so do not clutter the area. Low part quantities are preferable because they use less floor space, yet they require more replenishment cycles. In my experience, future kaizen teams always perform a second and third pass on material presentation as part of continuous improvement efforts. Therefore, you can consider this to be only the first attempt to reducing inventory in the plant. Remember, plantwide inventory reduction will not be accomplished during one kaizen event.

Select two part quantities and place them under a "common" or "uncommon" category. Common parts are used on every unit. If the line has product with multiple options, then there will be uncommon parts that are not always used. Since the daily volume is 72, use a common part quantity of 24 and an uncommon part quantity of half that amount, or 12. Since 24 is one-third of 72, this means that common parts will be replenished three times in one day. If a unit uses two of a given part, then quantity in the bin needs to be twice as much.

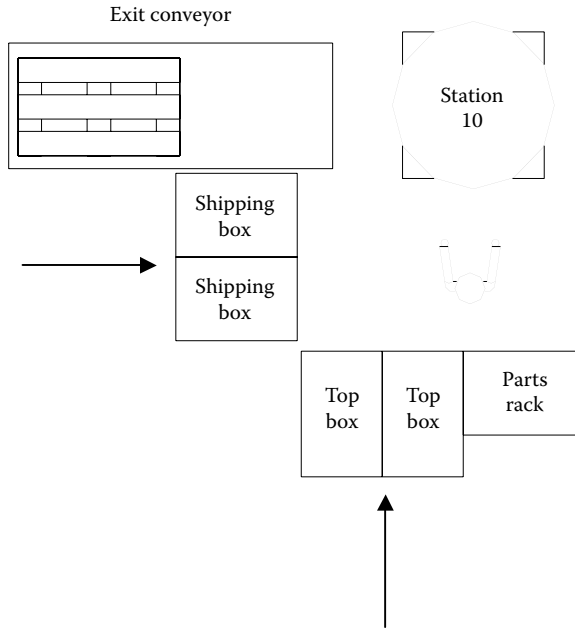


FIGURE 10.10
Large material presentation at workstation 10.

Large Part Use Not in Containers

Some material is too big to be placed in bins on a parts rack. Although it is not ideal, sometimes material needs to be placed in boxes and pallets at a workstation. However, a two-bin system is still applicable. Rather than stacking pallets on top of each other, it is safe to place the material side by side, and have the operator work out of one box or tote (see Figure 10.10).

The shipping and top boxes are placed around the workstation side by side. The operator can simply work out of one until it is empty. It is important not to stack two or more large materials behind one another. Also, material should always be placed at waist height, so that operators can retrieve the material easily and without injuring themselves.

When compared to other items that come on pallets or totes, boxes are handled in a unique manner. Unless the daily volume is very high, boxes are stored in a vertical position, which reduces the amount of floor space needed. The team should design carts or racks that allow a material handler to slide the flat box into slots. The operator can simply pull out the box and open it for installation. The two-bin system still applies, even when dealing with carts and racks. Two carts or racks are the same as two bins.

Subassemblies

Space needs to be allocated for finished subassemblies within the main assembly line. Except for the headlight, the remaining subassemblies will be made in a separate work cell, and material handlers will deliver them to the workstation.

Quantities also need to be established for subassemblies. Subassemblies not only take more room, they need to be presented at the appropriate height. We selected a part quantity of 24 for the individual components, but this number may be too high for large subassemblies, such as the main body panel and the trunk. On the other hand, 24 would be an appropriate quantity for some items, such as the tool and instruction kits. The quantities for finished electric bike subassemblies can be separated into large and small quantities. The subassemblies can be either stored in bins, if applicable, or properly secured in a row.

Large Subassembly	Quantity
Main body panel	10
Trunk	10

Small Subassembly	Quantity
Tool kit	24
Mirror	24
Instruction kit	24

Selecting the correct bin and container sizes is critical to keeping floor and shelf space to a minimum. A variety of sizes and shapes will be used, depending on the part. The team should put together a bin selection chart to help pick the appropriate bin size. Figure 10.11 shows a bin selection chart that can be used for this purpose.

Using the standard work sheets, the parts team should assign a bin designation to each part number, based on its size and quantity. Figure 10.12 shows the material list from workstation 10 and the bin designations for each part.

The parts team should do this exercise for all parts in the last five workstations and the headlight feeder. Miscellaneous items such as pens, operator identification, labels, and so forth, should also be assigned a bin. This exercise is a very effective project management tool because once the designations are assigned, the team can quickly collect the bins and set up the material.

After the bins have been selected and the team has filled the parts to the required quantities, the parts rack needs to be chosen. As mentioned before, mobile parts racks should be utilized whenever possible. There are a variety of racks that can be ordered from material storage suppliers. I have used

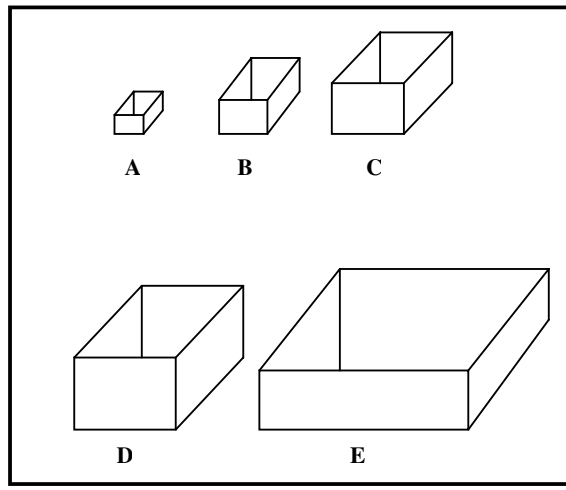


FIGURE 10.11
Bin selection chart.

Workstation 10 **Material and Bin Designation**			
Part Number	**Part Description**	**Bin**	**Designation**
13-1325-98	Mirror	E	Common
-	Tool Kit S/A	E	Small
-	Instruction Kit S/A	E	Small
13-2548-74	Battery Charger	E	Common
09-1144-15	Poly Bag	Bin	Common
07-3696-33	Blue Box Holder	E	Common
50-5540-50	Shipping Box	-	Common
50-5541-50	Top Box	-	Common
09-2215-00	Foam Wrap	D	Common
10-0055-44	Staples	A	Common
87-8895-64	Banding	-	Common
87-8325-11	Packaging Tape	C	Common

FIGURE 10.12
Bin selection chart of workstation 10.

FIGURE 10.13
Metal shelving.

these parts racks in many kaizen events (see Figure 10.13). They come with a selection of accessories that can be used to tailor fit the material and other items needed for the workstation.

However, more than likely, the red tag campaign identified material racks or other forms of storage that can be reused. These racks need to have enough space for the material and any shadow boards.

Day two is an action-packed day for the kaizen team. The team should try to complete construction on the last five workstations and the headlight feeder by the end of the day. However, since day three will be similar to day two, it is all right if action items from day two roll over into the next day.

The team should meet in the break out room before leaving to discuss the results of the day. The team leaders should explain that day three will be smoother because the training on workstation construction and part and tool presentation was part of day two. The team should be able to complete construction of the assembly line on day three.

Day Three

As usual, the team should first gather in the break out room to discuss the action items for the day. The last half of the assembly line has been almost

or completely constructed, so the team leader should assign a few team members to go out on the production floor and watch the operators perform their work. Since all visual aids, signals, labels, and other visual management tools will be completed on day four, the operators may have some questions about how the workstations are setup. Even though the line is more organized than before, without the correct visual aids it may become disorganized very quickly. This can be prevented by having some of the team members remain on the line until the shift is over.

The goal for day three is to construct the first five workstations and the subassembly work cell. The team leader should assign a group to work on the main assembly line workstations and another to construct the subassembly work cell. Day three should be less hectic than day two because the team leader does not have to discuss the two-bin system and tool presentation. Once the operators have finished for the day, the team can begin work on the assembly line.

The team needs to apply the same dimensional rules that were applied on day two. Except for workstation 1, the rest of the line is quite simple. Each workstation will have a rotating lift table and a parts rack, and a few will have disposal bins. Figure 10.14 shows the layout of the first five stations and the subassembly work cell.

Subassembly Work Cell

The subassembly work cell is close to the main assembly line. There should be enough space for material handlers to walk through safely. The main body panels are placed side by side, similar to the boxes in workstation 10. Parts needed to build the subassemblies are placed next to the main body panels, at point of use.

Operators will pull the necessary parts, perform the assembly, and place the completed subassemblies in the designated rack. The subassembly work cell should be placed 6 to 8 ft from the main assembly line, allowing material handlers to walk through safely. This type of setup promotes a nice even flow into the main assembly line.

Main Assembly Line

Workstation 1 is different from the other workstations. The standard work in this workstation is to install the frame to the shipping pallet. There are also a variety of smaller parts required to perform other work. The frame is

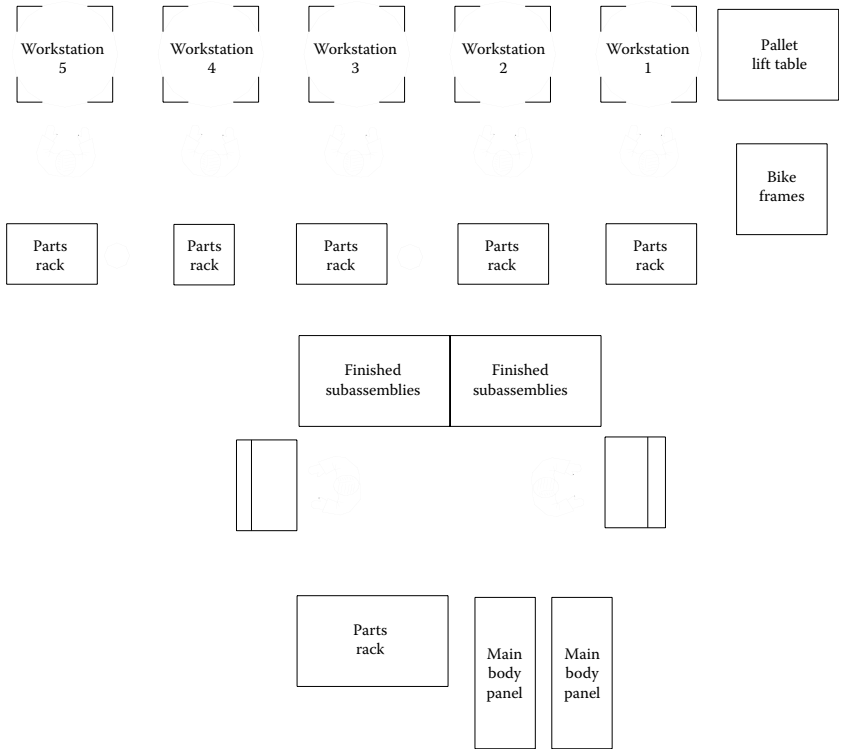


FIGURE 10.14
Top view of first five workstations.

made of aluminum, so weight will not be a factor, but the pallets are bulky and take up floor space.

The shipping pallets should be presented at waist height. Stacking them too high or too low will create wasted movement when retrieving them. Parts like the shipping pallet can be stored on a lift table. The pallet can be placed in any position that allows the operator to pull the pallet into the workstation. Figure 10.15 shows the side view of the pallet lift table.

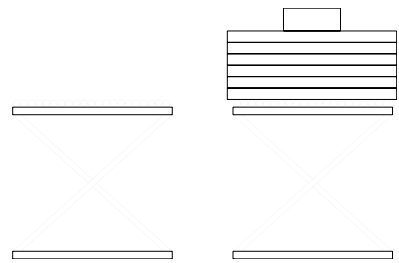


FIGURE 10.15
Side view of pallet lift table.

The frame has to be pulled out of the frame tote and placed onto the shipping pallet. It is not necessary to use a lift table to present the frame to the workstation. As long as it is waist high, the operator can simply pull out a frame and place it on the pallet for installation.

Floor space is the only real issue in workstation 1. The frames and the shipping pallets will not be set up on a two-bin system, because having two containers of both parts would take up too much space and create lengthy parts retrievals. The kaizen team will have to establish the appropriate visual signals on day four, so the material handlers can replenish before the operator depletes his supply.

The team should take its usual lunch break and have a midday meeting. At the end of the third day, the line should be ready for the implementation of visual management. The team should gather in the break out room to discuss the day's events. Did they complete line construction? Has maintenance finished installing the tools and created the shadow boards for each station? The team leader should take the team out to the production floor and walk through the line. Although there is one more day of work left to go, the team should be happy with what they have accomplished so far.

Chapter Summary

- The team should come up with two assembly line designs to review.
- Line construction needs to be complete by the end of the third day.
- Maintenance should verify all equipment is working properly.
- The internal machine shop or outside contractor should start building the tool stands for the ten main assembly workstations.
- Tools will be presented with the tool stands using tool retractors or on a shadow board.
- Implement the two-bin system for part presentation in the workstations.
- Use a bin selection chart for choosing the appropriately sized bins.
- Subassemblies need to be separated into a large or small size category.
- Place the bins, subassemblies, and the shadow boards on mobile parts racks.
- The team should complete line construction during days two and three so the implementation of visual management can be done on day four.

11

Day Four

Visual management is the key to running a lean assembly line. It reduces the amount of firefighting and provides real-time information on the progress of the line. The key to visual management is creativity. We use visual aids every day and they become so commonplace that we sometimes forget they are even there. Imagine what it would be like driving to work every day without road signs, speed limits, road dividers, turn lanes, turn signals, off-ramp signs, and the many other visual aids we use on the road. A manufacturing floor should be set up to run on its own and allow management and engineers to react to the visual aids. Visual management is typically associated with making production information visually available in order to track progress. However, it does far more than just track progress. Visual management is about having the appropriate signals and queues that allow the manufacturing process to operate on its own, directed by people only when required. Day four is dedicated to implementing visual management into the line. Figure 11.1 shows the required items for day four.

The final day of implementation will be busy. It is a day involving creativity, as well as thinking outside the box. The visual controls and systems will be implemented into the assembly line, allowing it to operate virtually unattended. A lot needs to be accomplished by the end of this day. The team leader should go over the action items for the day and assign team members to the following specific tasks:

Workstation signs and parts rack signs
Floor taping and designations
Two-bin system labels
Subassembly build levels
Installing shadow boards and tower lights
Production control board
Takt monitor

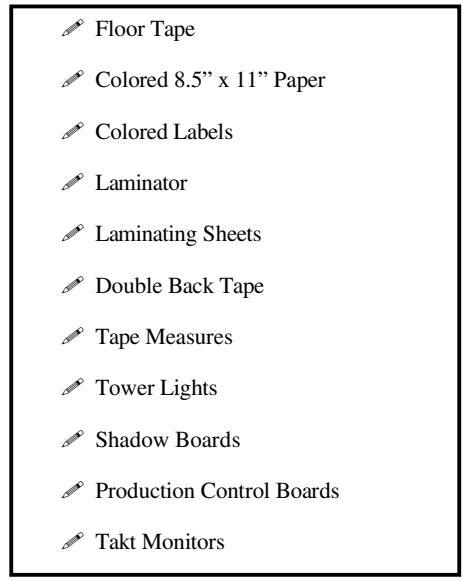


FIGURE 11.1
Day four necessities.

Workstation Signs and Parts Rack Signs

Although this task is simple, it is somewhat time consuming. Each workstation and parts rack requires identification. One team member should be responsible for making and installing all workstation and parts rack signs. First, an accurate count of all workstations and parts racks needs to be done to ensure that workstation or parts rack designations are not duplicated. There are ten main assembly line workstations, each containing one parts rack. It is good practice to identify a workstation by its number in the assembly line. Print the number on an 8.5×11 in. sheet of paper and then laminate it for protection.

A sign serves two purposes. It identifies the workstation and it is a part location designation. The workstation signs should be installed high enough to be seen from a moderate distance away. Figure 11.2 shows the placement of the sign for workstation 10.

Workstation signs for the headlight feeder will be different. Since signs 1, 2, and 3 are used for the main assembly line, and should not be duplicated, place an H in front of the workstation number on the signs that will clearly identify the headlight feeder workstations as H1, H2, and H3.

This exercise is fairly simple, so the team members should be allowed to come up with creative ways to identify the workstations and all parts racks on the floor. Anything is acceptable as long as there are no duplications.

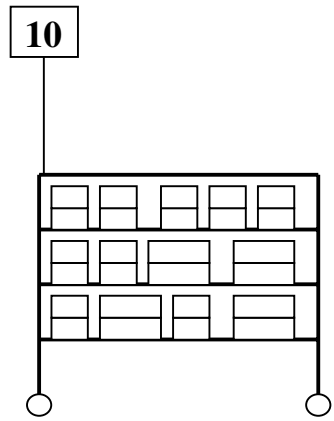


FIGURE 11.2
Workstation sign.

Floor Taping and Designations

This exercise will require two team members. Anything that is sitting on the floor must be identified, just like the workstations were in the prior activity. Lift tables, parts racks, pallets, disposal bins, workbenches, the exit conveyor, and so forth, should be identified. Floor tape comes in a variety of colors and styles. Yellow floor tape is the most popular, as it provides a bright outline around the items on the floor. After every item is outlined by yellow tape, the two team members should create floor signs that identify each item. All labels, signs, and other identification should be laminated to protect them from damage, as floor signs can easily become dirty or torn. The lamination material will protect the signs, allowing them to last for a longer period of time.

Make sure the floor surface is clean. Use double-sided tape, and make sure it is secured firmly to the floor. It is also a good practice to place clear packaging tape over the floor sign for additional protection. Figure 11.3 shows yellow tape outlining the items in workstation 10. Figure 11.4 shows what floor designation signs would look like for workstation 10.

Floor signs for parts require a part description, part number, and quantity. Parts racks and workstations can have the same designation. It is good to have two floor signs for each of the items on the floor so that they can be identified from either side. Allow the entire day for the two team members to complete this exercise. Figure 11.5 shows the parts rack for workstation 10 after the installation of floor designation and workstation signs.

Having a workstation sign that can be seen from a moderate distance away, as well as a parts rack designation on the floor, makes workstation 10 easily identifiable.

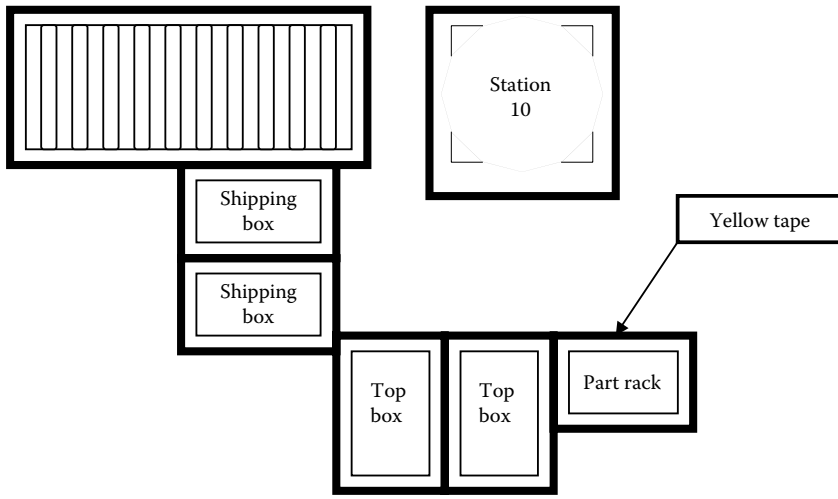


FIGURE 11.3
Yellow floor designation.

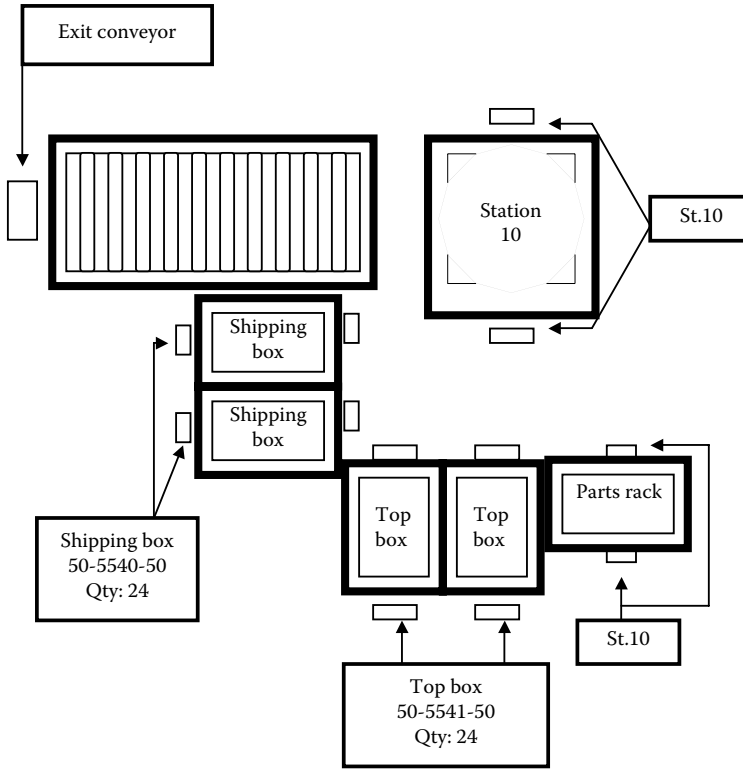


FIGURE 11.4
Floor designation sign.

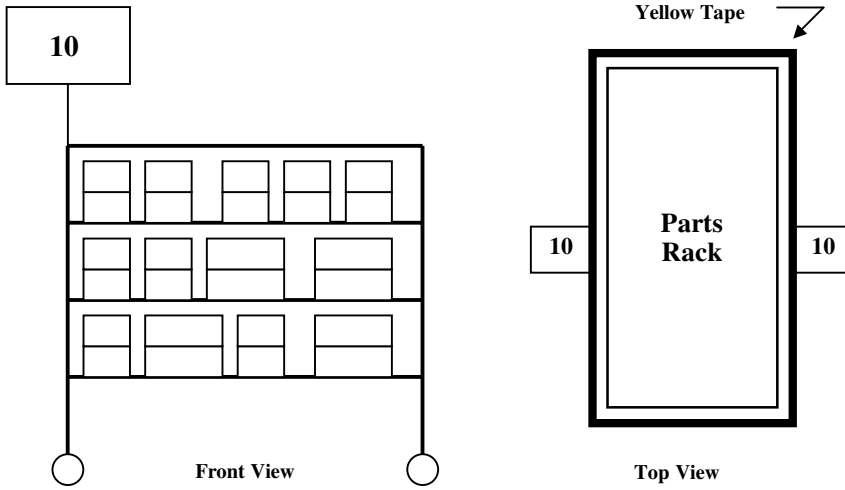


FIGURE 11.5
Parts rack designation.

Two-Bin System Labels

This activity will require about six team members (depending on the number of bins in the assembly process), and it must be completed by the end of the day.

Color Labels

The parts used for each assembly line should be color coded to help reduce the possibility that a bin of parts coming from the storeroom will be placed in the wrong line. For example, if there are three assembly lines, in the plant, an A-line, B-line, and a C-line, the A-line bins could have orange labels, B-line bins could have yellow labels, and C-line bins could have green labels. With this type of identification, an orange bin placed in the C-line, will be easily identified as the incorrect parts for that line. This method allows production supervisors and material handlers to see the mistake from a long distance away, and thereby remedy the situation much more quickly.

Some companies use different colored bins instead of colored labels. This is perfectly acceptable because it serves the same purpose. As long as the bins can be associated to a particular line, the visual management of those bins is accomplished.

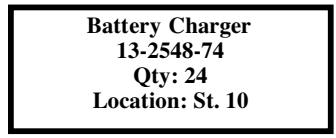


FIGURE 11.6
Workstation 10 bin label.

Two-Bin System Assignments

This exercise requires a group of six team members that will each work on one specific task. Using the bin selection charts for each workstation, a member should be assigned to make the labels. Another team member should be responsible for laminating the labels and cutting them out. Label makers work well for this exercise, as long as colored labels can be used. If colored bins are being utilized, the labels should be the same color. The other four team members assigned to this activity will continue to fill out the two-bin system work sheets and retrieve the finished labels for placement in the workstations.

Each label must contain the part description, part number, quantity, and the location on the assembly line. Three labels are required for each part: two labels for each of the bins and one label for the parts rack where the bin is located. Figure 11.6 shows an example of a bin label for workstation 10.

The bin labels serve as an added visual aid for the material handler. Each label accurately identifies the contents of the bin. The combination of colored labels, floor designations, and workstation signs clearly identifies the location of the bins, making the parts easy to find. Figure 11.7 shows a sample of some of the labels found in workstation 10.

This system is highly effective, allowing material to flow easily in and out of the workstations. Material handlers and assemblers work together to ensure that the parts are available when needed and the quantity is accurate to keep the line at takt time.

Subassembly Build Levels

The ideal situation is when the entire product is built on the main assembly line. However, many companies have certain constraints that do not allow for this, so installing feeder lines and other subassembly work cells will accomplish the task just as effectively.

The headlight feeder line is set to takt time and a completed headlight is ready for installation into workstation 6 when needed. The electric bike line also uses a subassembly work cell to make the small, simple, quickly built assemblies for the main line.

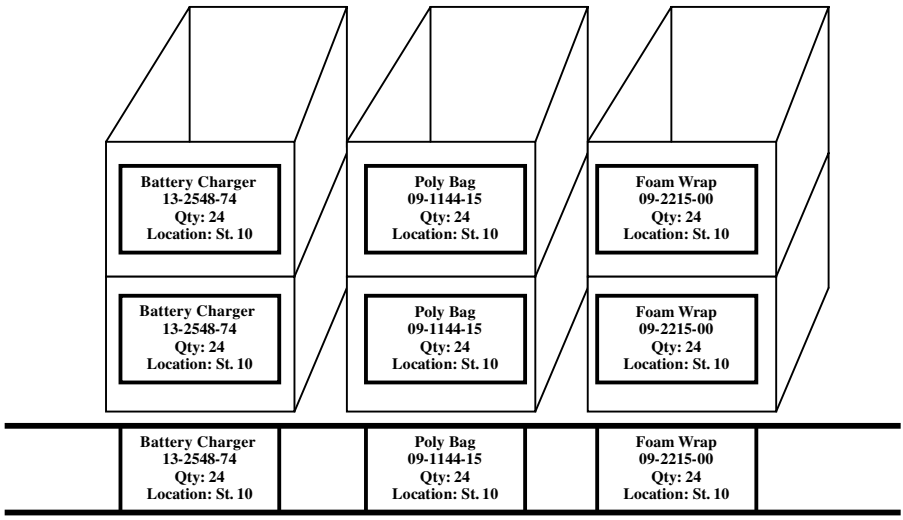


FIGURE 11.7
Two-bin system in workstation 10.

If proper visual aids are not in place, operators may overbuild items that are not needed, which will slow down the main assembly line. In situations like this, build levels should be created telling the operators when to stop building or start building. They can switch back and forth as a team, building only the appropriate quantities at the appropriate times. The build levels for storage on the main assembly line were established on day four, and these same quantities should be applied to the subassembly work cell.

Large Subassembly	Quantity
Main body panel	10
Trunk	10

Small Subassembly	Quantity
Tool kit	24
Mirror	24
Instruction kit	24

The team leader should select team members to create and implement visual aids for the subassembly operators and for the main assembly operators. In the subassembly work cell, there are two designated racks for placing finished goods. Based on the quantities above, build level signs should be made to direct the operators. Figure 11.8 shows a sign that can be used for this purpose.

For example, the operators are required to build 24 tool kits and then move onto the next subassembly station that is empty. The build quantity sign

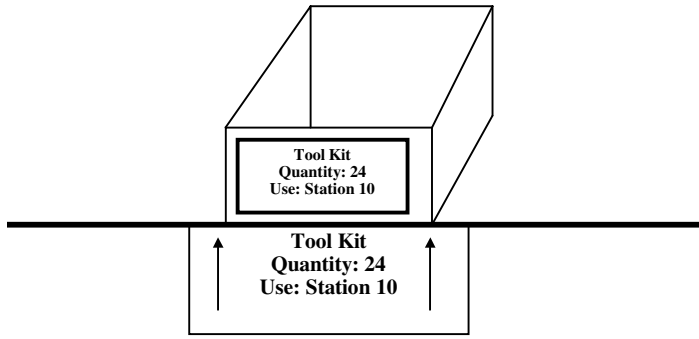


FIGURE 11.8
Subassembly build quantity.

should also be in workstation 10 on the main assembly line where it is consumed. The line is designed such that 24 tool kits is a 3 hr supply. It takes 0.82 min, or approximately 50 sec, to assemble a tool kit; therefore, the subassembly operator has adequate time to build the required number of kits before the material handler comes to retrieve them. The empty bin or row where a finished subassembly is located is the visual signal to start building additional kits. As long as the subassembly operators follow the build level requirements, they will not get behind or build too far ahead.

Installing Shadow Boards and Tower Lights

Maintenance should have the shadow boards ready for installation by day four. Since most of the air tools are hanging above the workstations on retractors, the shadow boards will be small. They can be installed on workstation parts racks, or any other racks that are placed optimally. Since the headlight feeder and the subassembly work cell do not use lift tables, the shadow boards can be installed directly on the workbench.

Tower lights are a critical aspect of visual management. They are very common, but are frequently used incorrectly, or not at all. Tower lights are the communication system between operators and the rest of the plant. There is a variety of tower lights on the market and every company applies a different meaning to each color. The most effective and the simplest types of tower lights are those that only have three colors; red, yellow, and green (see Figure 11.9).

Red can be used for signaling a major problem in the workstation, such as a quality issue, tool or lift table malfunction, out of parts, or just an operator request to speak to the production supervisor. When the red light is on, any support staff in the area can stop whatever they are doing and address the operator.

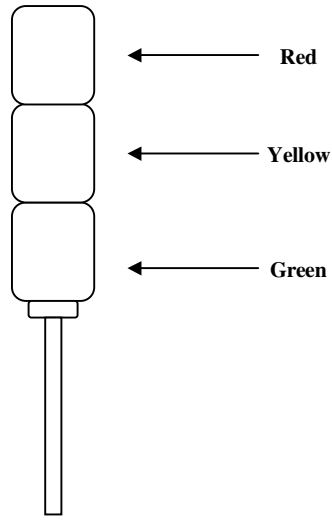


FIGURE 11.9
Tower lights.

Yellow can be used when there is a minor issue in the workstation. This color can also be used to signal a material handler when the parts bin is empty, or the quantity of subassemblies is getting low. The material handler should visit the workstation in question to determine what the operator needs.

A green light indicates to the entire facility that everything is operating fine and the unit will move within the desired takt time. Tower lights should be installed at every workstation, including feeder lines and subassembly work cells (see Figure 11.10).

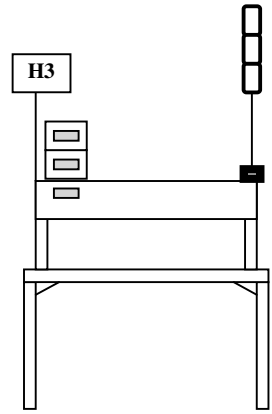


FIGURE 11.10
Workstation H3 in headlight feeder.

Production Control Boards

The goal of any lean assembly line is to move a unit every takt. The electric bike line needs to move every 4.84 min to ensure that 72 bikes are built every shift. A production control board is a very good visual tool for monitoring this pace.

Production control boards can be chalkboards, flip charts, or dry erase boards. They should be placed near the last workstation and updated every takt. Two production control boards may be necessary for one assembly line, depending on the volume. The electric bike line is designed for 72 units a day; therefore, using two boards would be more effective.

Creating a production control board does not take a lot of time and can be done at any time during day four of the kaizen event.

Takt Monitor

The last item to be installed by maintenance is the takt monitor. The ideal place for a takt monitor is at the last workstation, next to the production control board. Used together, the takt monitor and the production control board allow operators and supervisors to effectively monitor the pace of the line. Many takt monitor manufacturers offer special networking software, allowing managers to view the progress from their own computers. This is a nice option; however, a production manager should stay on the factory floor as much as possible.

Implementing visual management is very important in a lean environment. Without daily direction and accurate information on progress, management and engineers will slowly return to the previously used method of putting out fires as they occur. Visual management allows support staff to react to signals indicating deviation from standard and resolve problems before they occur, rather than after.

The team's goal should be to complete the items listed in this chapter on day four. Approximately 60 min before the end of the day, the team should meet in the break out room. They should reflect on what they have accomplished, and the team leader should document the individual achievements of the team which will be included in the closing presentation on day five.

Chapter Summary

- Visual management is the key to providing real-time information on production performance. It also provides direction for the operators on what to do, when to do it, and how often.
- All items on the floor need colored floor tape outlining their location.
- All parts and subassemblies should have a label describing the items, quantity, and location.
- Subassemblies should be assembled to build quantities.
- Shadow boards should be installed into the workstations.
- Tower lights allow operators to communicate to material handlers and the support staff.
- The use of production control boards and takt monitors provides management and operators with line flow progress and problems.

12

The Final Day

The closeout presentation should be scheduled for late morning, allowing the team leader time to prepare and the team to rest at home until the time of the presentation. Unless the kaizen champion is giving the presentation, the team leader may need to meet with the champion to discuss how the presentation should be organized. The purpose of the presentation is to show the entire facility what the team has accomplished, highlighting all the improvements made to the business metrics. Figure 12.1 shows a list of the required items needed for the final day.

The closeout presentation also includes a tour of the new assembly line, giving the attendees a chance to see the line operating under its new conditions. The presentation of accomplishments and improvements should be approximately 30 min. The walkthrough should last until all questions or concerns have been addressed. The presentation should include:

1. Name of the team leader, team members, and everyone's title
2. Name of the assembly line or area
3. Kaizen event date
4. Anticipated results
5. Actual results
6. Before and after pictures
7. Discussion of the systems implemented (e.g., two-bin system, 5S, single piece flow, build levels, tower light, tool presentation, etc.)
8. Lessons learned
9. A 30-day mandate (to-do list)

The 30-day mandate is a list of unfinished items from the kaizen event. Every event will have a to-do list, and team members should be assigned to complete them within 30 days. There are rare occasions when these items will require more than thirty days; however, the kaizen governing committee

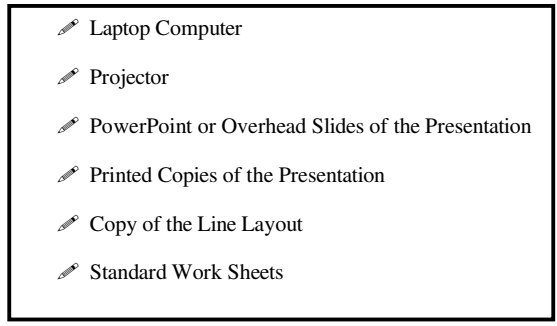


FIGURE 12.1
Final day necessities.

should assist the team in completing their tasks within 30 days when possible. Items to be completed in 30 days include:

5S audit sheets
5S tracking sheet
Workstation instructions
Quality at the source
Employee cross-functional matrix
Rate cards
Standard work for three different rates
Line and operator placement map
Standard work book

5S Audit Sheets

The kaizen team will have completed the first four Ss of the 5S portion of the event. They successfully sorted, straightened, scrubbed, and standardized the various aspects of the assembly line. Each workstation has the same rules and regulations for operation, leaving very little to chance. The biggest challenge for the plant is to sustain the changes that were made during the event. Production control boards and takt monitors will provide real-time data on the pace of the line; however; a 5S audit sheet should be made to help monitor ongoing cleanliness and organization (see Figure 12.2).

5S audits should be performed by the kaizen champion on a weekly basis. The best time to conduct these audits is when the line is not in operation. Tools, bins, parts, garbage bins, racks, and documentation should always be returned to its intended location at the end of the day,

5S Audit Sheet

Team

Audit Date

Auditors

# of Yes's / 16 = %

Sort (Get rid of unnecessary items)		
Work Station and/or area is clear of all non-production required material	Yes	No
Obsolete or defective parts have been removed and tagged	Yes	No
Unnecessary equipment has been removed from the area	Yes	No
Straighten (Organize)		
Are cabling/air lines routed neatly?	Yes	No
All equipment and tools are clearly marked and well organized	Yes	No
Locations and containers for items, parts, and supplies are clearly marked	Yes	No
Queue levels have been set, are clearly marked, and organized	Yes	No
Scrub (Clean and solve)		
Floors, work surfaces, equipment, and storage areas are clean	Yes	No
Garbage and recyclables are collected and disposed of properly	Yes	No
Excess pallet and packaging materials are cleared out of area	Yes	No
Standardize (Tasks)		
Standard work is displayed	Yes	No
It is obvious through visual management whether tasks have been done	Yes	No
Sustain (Keep it up)		
Standard work is being followed	Yes	No
Production control boards are being used on a daily basis	Yes	No
Work instructions are displayed with correct revision	Yes	No
Work area is clean, neat and orderly with no serious unsafe conditions observed	Yes	No

GREEN = 81% to 100% — Area is 5S compliance

YELLOW = 66% to 80% — Area meets minimal standards

RED = 0% to 65% — Area needs immediate attention

FIGURE 12.2
Electric bike line 5S audit sheet.

making it available for the next shift or next day. Aisleways and workstations should be clear of any non-production items. Lift tables (if applicable) should be brought back to set height, giving the line a nice, uniform appearance. Remember, the effective hours includes 15 min for 5S and cleanup; therefore, the production supervisors should make sure this occurs at the end of every shift. The kaizen champion should provide these results to the production manager weekly.

5S Tracking Sheet

As time goes on and more kaizen events are conducted, a 5S tracking sheet should be used to monitor all areas of the plant. The 5S audits are done every week and the weekly results should be posted where all operators can see them. A good location for this tracking sheet is next to the kaizen event communication board. Posting the weekly results promotes a level of com-

petition among operators of different lines, helping to motivate them to keep their areas clean and organized.

Work Instructions

Work instructions are the most important documents in an assembly line and they should be made workstation specific. It is common practice for many companies to place all the work instructions for an assembly line into one master binder, and then place it in one designated location. The more effective process would be to keep the specific instructions for each workstation within the specific workstation, where they can be easily referenced.

The key to successful work instructions is to make them easy to understand and easy to follow. It takes special talent to translate technical information about a product into a simplified language. The best way to accomplish this is to reduce or eliminate unnecessary verbiage; icons, signs, and pictures can be used to illustrate the assembly work (see Figure 12.3).

Operators that speak a foreign language or have difficulty reading can be trained using assembly icons and definitions. Your company should develop a list of icons and symbols that can be used to explain assembly operations. This list will be used during new employee orientations and for any required training.

The standard work sheets should be used as a reference when creating work instructions. Using CAD software or digital images, the work instruc-

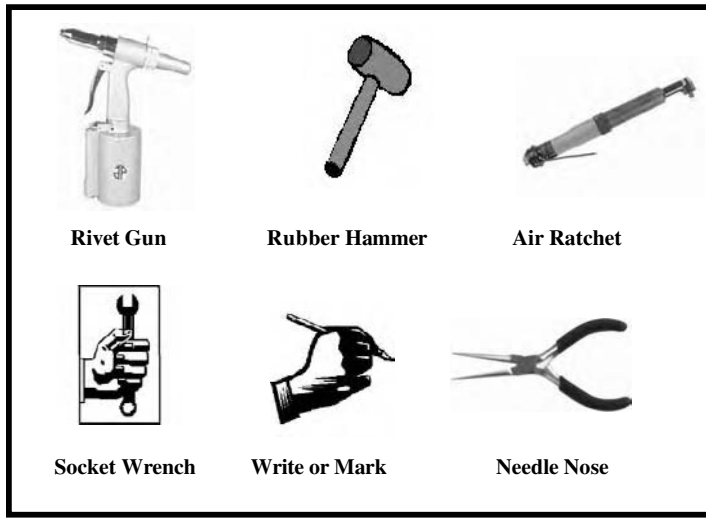


FIGURE 12.3
Work instruction assembly icons.

tions should contain only the part and the specific work steps for the particular workstation. Do not include drawings or pictures of parts or steps that are not associated with that workstation, as that will cause operator confusion.

Each picture or drawing should be inserted sequentially, in the exact order of the work process. Remember, the work instructions are intended to guide the operators through all the steps necessary to perform their specific task at their assigned workstation.

Work instructions should be printed on 11 × 17 in. paper and then laminated for protection. They should be hung in each workstation for easy access. The work instructions can be placed anywhere as long as the operator does not have to leave his workstation to find them. Just be sure not to place the work instructions where they can obstruct the operator's view of the product.

Several opinions exist regarding the importance of work instructions. Work instructions are designed to serve two purposes: training and reference. Operators will not use the work instructions every time they install a part. Once they have been trained and have become comfortable with their surroundings, work instructions will only be used as reference. New operators are most likely to reference them frequently during their learning phase.

Work instructions should contain all the necessary information to build the product:

- Drawings or pictures of the work
- List of the work content
- Symbols and icons
- Part numbers
- Part descriptions
- Part quantities
- Sequence number from the standard work sheet
- Safety information
- Station number
- Station description
- Product name
- Page numbers
- Revision numbers
- Approval signatures

An example of a work instruction containing these attributes is shown in Figure 12.4.

Company Z

Work Instruction

Unit:	A10		Operation Sub
	Process Identification Trunk Lock Bracket		Page 1 of 1
Sequence	Work Content		
10	Install (4) Rivnuts into the Lock Bracket		
Item	Part #	Description	QTY
1	68-62718-00	Lock Bracket	1
2	34-06051-104	Rivnuts	4

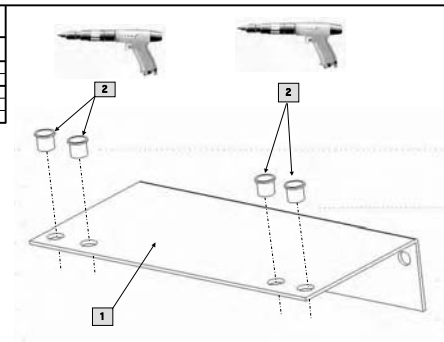


FIGURE 12.4
Work instruction.

Quality at the Source

Traditional quality control methods, such as incoming inspections and 100% inspections of the product, will not catch all the errors or defects. Although these inspections are important, they are not a means of building quality into the process. Product quality can make or break a company's reputation, regardless of how well an assembly line runs. Cost of quality can be high with excessive defects, rework, and scrap. The most effective way to build quality into a process and product is by implementing quality at the source.

Quality at the source places the responsibility of quality into the hands of the operators or at the point of assembly. Operators in each workstation throughout the assembly line are required to check and catch errors before they become defects. If a part is installed incorrectly at the first couple of workstations and it is not caught until final inspection or testing, it may be too late to repair the problem. It is better to catch these errors early to avoid costly remakes or scrap. Of course, in the worst-case scenario, the entire unit will be scrapped.

Use the standard work sheets or the work instructions as a resource to identify the critical quality responsibilities of each workstation. Additionally, gather historical quality data from failed inspections or customer complaints. Use this information to design quality into the process. Some possible quality checks include checking for missing parts, checking for proper

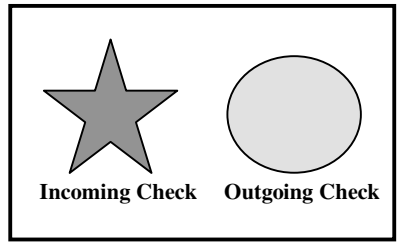


FIGURE 12.5
Quality icons.

functioning, checking for the right fastener, and checking for correct wiring of a wire harness.

When selecting the quality checks that should be done, make sure to choose those that take minimal effort and as little time as possible. Most quality checks should take less then 5 sec. Operators are not inspectors, but they should be assigned quality checks that are simple and can be done quickly.

Each operator should be required to perform one incoming and one outgoing quality check. After pulling the unit into their workstation, they should verify one particular item before starting their work. After they have completed their assembly work, they should check one item related to their own work. Once you have selected the appropriate checks, they should be added to the work instructions. Special quality symbols should be created to illustrate incoming and outgoing checks. For example, a green star could represent an incoming check and a yellow circle could represent an outgoing check. The quality icons would have arrows coming from them pointing out what needs to be checked. This allows ESL (English as a Second Language) and colorblind operators to understand their meaning (see Figure 12.5).

Many operations will be slightly under takt time even with the 85% rule. The assembly line operators have ample time for performing minor checks throughout the process, and thereby can ensure that a quality product is built.

Employee Cross-Functional Matrix

After implementation of 5S, standard work, and visual management, an operations manager should staff his line with good quality operators. This type of process requires highly trained, quality-conscious individuals; training will be discussed in more detail in Chapter 13. The operations manager and the production supervisor for the perspective line should have an understanding of their employees' skill levels and which workstations would be best suited to each. An employee cross-functional matrix is a good visual tool to use for this purpose. The electric bike line's employee cross-functional matrix would look like the one shown in Figure 12.6.

Electric Bike Line
Cross Training Matrix

Main Assembly										
Operator	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Station 6**	**Station 7**	**Station 8**	**Station 9**	**Station 10**
Mark.G	C	T								
Tammy S.	C	C	T							
Kyle T.		C	T	T						
Bill F.			C	CT	C					
Pedro G.				T	CT	CT				
Jill B.					C	C	T			
Janet Y.						CT	CT	CT		
Jeff B.							T	T	C	
Wanda W.								CT	C	T
Gary A.									T	T

Head Light Feeder			
Operator	**Station 1**	**Station 2**	**Station 3**
Phillip R.	CT	CT	C
Rahael Q.	C	CT	T
Sean H.	C	C	C

Work Cell	
Operator	**Assembly**
Mike S.	CT
Jim M.	CT

Classifications	
T	Trained
C	Certified
CT	Certified to Train

FIGURE 12.6
Employee cross-functional matrix.

The workstation for the main assembly line, the headlight feeder, and the subassembly work cell are all identified across the top of the matrix. Operator's names are placed along the side. Operators can be categorized in three skills levels:

Trained (T)
Certified (C)
Certified to train (CT)

The first category is trained. This is essentially an entry-level employee that has gone through the required training process and can work in a particular workstation. A trained operator understands the two-bin system, the tower lights, how to use the tools in the workstation, how to perform the required work, and how to perform the quality checks. A trained operator has demonstrated that they can finish their work within takt time, but is given some leeway for not finishing in time because they are still on a learning curve.

When a trained operator has demonstrated his ability to work within takt time for one full week, he or she can become a certified operator. Certified operators can perform their work without supervision and can complete

their responsibilities every takt. Certified operators can also identify quality errors and make quick decisions on what to do.

A certified operator can advance to certified to train status after working with no errors in a specific workstation for 90 days. He or she has proven to be a reliable employee and can now train new employees to work in that specific workstation.

Eventually, all operators should be trained in the work content and requirements of the workstations that precede and follow theirs. During changes in volume, operators will be required to move from one workstation to another as needed to keep the product flowing. If an operator catches an assembly error made in the previous workstation, they should be able to rectify the problem. The more workstations an operator is familiar with, the more flexible he is as an employee. It should become company policy to award pay increases or other incentives to operators who are proficient at many workstations. Of course, the ideal situation would be one where operators are trained to work anywhere on the entire line, including the test stations.

Rate Cards

Assembly lines should be designed to operate at three or four different rates. Although the station is physically constructed for one particular volume, there should be standard work set for at least three different rates. A rate card is a small 3×5 in. index card that outlines important information about the different rates:

Daily rate
Takt time
Manpower

The rate card for the electric bike line consists of three different rates (see Figure 12.7).

Workstation requirements will not change, because employees can be flexed, moved from station to station. Flexing will be discussed in Chapter 13. However, manpower requirements will change based on the different rates. Each assembly line should have a different rate card, color coded with the same color as the labels on the associated part bins. This ensures that the supervisor does not use the incorrect rate card.

Managers can use the rate card as a guide to adjust manpower when volumes change or when employees are absent on a particular shift. For example, to build 72 units in a day, the assembly line needs fifteen dedicated operators. If four people call in sick, the supervisors should default to the next rate indicated on the rate card. Building at the regular rate without

Electric Bike Line			
Daily Rate	72	60	48
Takt Time (Minutes)	4.84	5.80	7.26
Main Assembly Manpower	10	8	7
Headlight Feeder Manpower	3	2	2
Sub Assembly Manpower	2	1	1
Total Manpower	15	11	10

FIGURE 12.7
Electric bike rate card.

enough employees should never be attempted; it will only result in quality issues. To avoid having to drop rates, the production department should have backup operators, or floaters, that have been trained in all workstations. However, anything can happen, so the best course of action is to build according to the number of operators present.

Standard Work for Three Different Rates

Volume requirements will change throughout the year. I am aware that volume changes are different from one company to another; however, standard work sheets should be created for each rate selected. The electric bike line has three rates; 72, 60, and 48. Standard work for 72 units was completed prior to the kaizen event.

Operators will be removed from the line during lowered rates, and they need specific, alternative assignments. An operator is required to do a certain amount of work content in their assigned workstation and in the workstations near them. The rate card indicates that 11 operators are needed to build 60 units a day. Therefore, there should be 11 standard work sheets explaining the assignments. When the rate falls to 48, then there are only ten standard work sheets. Figure 12.8 shows the standard work sheets for the first two operators when 60 units a day are required.

Standard work sheets for decreased volumes look a little different than the standard work sheets for full capacity. When operating at the design rate of 72, the assembly line is fully staffed and the standard work sheets are workstation specific. When the rate decreases, the standard work sheets are operator specific, rather than workstation specific. The sheets explain what work content is completed and at what workstation the operator needs to flex to. In Figure 12.8, the standard work sheet for the first operator shows

Operator 1		
Workstation	**Work Content**	**Time**
1	Install Frame to Shipping Pallet	3.17
1	Install (2) Shock Absorbers to Front Forks	0.25
1	Install Front Forks to Frame	0.82
1	Install Front Wheel to Front Forks	0.36
2	Install (4) Black Rubber Bumpers to Frame	0.26
2	Install Battery Pack into Center of Frame	0.60
	Total	**5.46**

Operator 2		
Workstation	**Work Content**	**Time**
2	Install Battery Pack into Center of Frame	0.60
2	Install Serial Number Label to Frame	0.15
2	Connect Electric Motor to Voltage Tester	0.56
2	Test Electric Motor	1.25
2	Place Operator I.D. Label on Electric Motor	0.18
2	Remove Electric Motor from Voltage Tester	0.55
2	Install Electric Motor to Frame	0.66
3	Install Fuse Box to Frame	0.56
3	Install Horn to Frame	0.27
3	Install Drive Chain to Electric Motor	0.16
3	Install Rear Wheel Assembly and Wrap Drive Chain around Sprocket	0.92
	Total	**5.80**

FIGURE 12.8
Standard work sheets for operators 1 and 2.

that he must perform four work elements in workstation 1, and then flex into workstation 2 to perform two tasks. The second operator is required to perform seven tasks in workstation 2, and then flex to workstation 3 to perform four assembly tasks.

Line and Operator Placement Map

A simple map of the assembly line should be created to give quick, visual representation of where operators should be placed (see Figure 12.9).

Operators are placed into particular workstations depending on how the work content is distributed during lower volumes (see Figure 12.10). The production supervisor can use the line rate card and this map to place operators in the appropriate workstation when volume decreases. The placement map is derived from the standard work sheets. The three rates on the electric bike line are 72, 60, and 48. There will be three sets of standard work sheets and three placement maps for each of those rates.

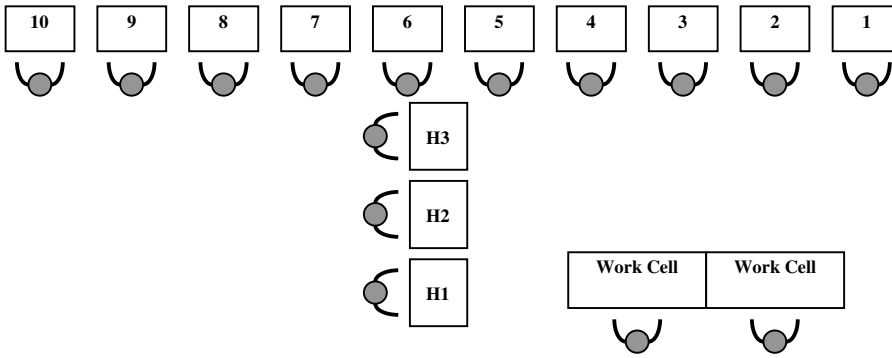


FIGURE 12.9
Operator placement map.

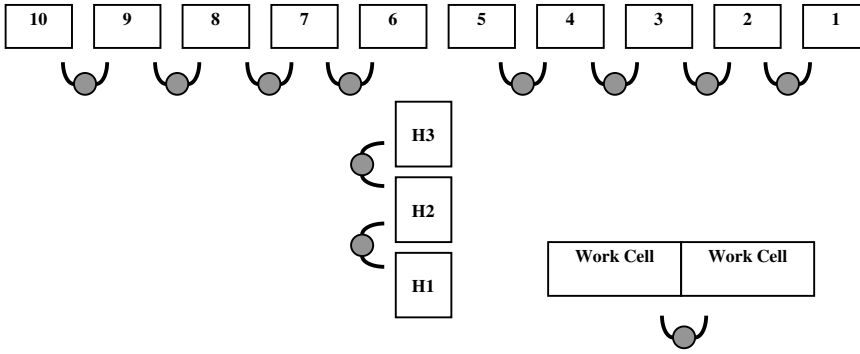


FIGURE 12.10
Operator placement map for 60 units.

Standard Workbook

The last item on the 30-day mandate is the standard workbook. Accompanied by the rate card, it is the only resource needed to manage and operate the assembly line. Some companies refer to it as their operations bible. This book contains all the necessary information about the assembly line. The standard workbook should contain the following items:

Standard work sheets for all the workstations
Standard work sheets for the other two rates
Work instructions for every workstation
Employee cross-functional matrix
Employees' vacation schedule

Operator placement maps for the three different rates

The rate card

Upcoming kaizen events and participants

The standard workbook also represents a crowning achievement for the company. It is the compilation of all the planning and work that was involved in designing and constructing the assembly line. Next to company policies and mission statements, it is one of the most important documents in the entire facility.

Thirty days should be sufficient time to complete all the action items on the list. The kaizen governing committee will review the action during their next meeting and address anything that is preventing completion by those responsible. Typically, team members who just participated in their first kaizen event may not understand the importance of completing their action items after returning to their usual responsibilities. This is a part of the culture change that needs to occur among the salaried support staff. After a few kaizen events, employees will become accustomed to change, realizing that their participation and responsibilities on a kaizen team are just as important as their regular responsibilities.

Line Tour

After the team has reviewed the accomplishments, the attendees should be invited to tour the new line. Although the presentation is important, they will get a better feel for the improvements by seeing them in reality. This is the chance for them to experience the changes firsthand.

The team leaders should escort the viewers through each workstation, describing the improvements that were made, and explaining why they were necessary. An explanation of the two-bin system and the subassembly build system provides a better understanding of how material will be delivered to the line. Explain how the tower lights work and what each color represents. Show them the production control board and the takt monitor, explaining the importance of using them on an hourly basis. Allow the group to ask questions about the line.

After the tour, take the employees to the red tag area and show them the pile of items that were removed during the red tag campaign held on day one. This is a good way to end the presentation because the pile represents all items in the old line that contributed to inefficiency and waste.

As a final step, the team leader should meet with the plant manager, the engineering manager, and the kaizen champion to discuss any final thoughts or concerns. The members of the kaizen governing committee should be invited into the team work area, then congratulated for their hard work and

a job well done. The end of a kaizen event is very fulfilling. There is a great sense of accomplishment, which builds morale and creates momentum for the next event. The last item on the list is to clean up the kaizen team work area. After the team has completed the cleanup, they should be allowed to go home for well-deserved rest and relaxation.

Chapter Summary

- A closeout presentation is conducted on the last day of the kaizen event.
- The team leader is responsible for gathering all the necessary items for the presentation.
- The presentation should cover:
  - Names of the team members and team leader
  - The line or area
  - Anticipated results and actual results
  - Before and after pictures
  - Team member's accomplishments
  - Lessons learned
  - 30-day mandate of action items
- Work instructions should contain minimal words.
- Work instructions should utilize icons and symbols to demonstrate assembly.
- Quality responsibilities should be described using an incoming and outgoing symbol.
- An employee cross-functional matrix should be used to monitor the training levels of the operators on the line.
- There should be three sets of standard work sheets based on three different volume requirements.
- A rate card and operator placement map can be used as a reference for the production supervisor on manpower requirements and placement for all three rates.
- A standard workbook is an accumulation of all the necessary information needed to manage the assembly line.
- The closeout presentation concludes with a tour of the new line and the red tag area.

13

Training and Accountability

The results you achieve and maintain after the kaizen event will depend on the level of training and accountability that is instilled in the operators. Additionally, there are rules and procedures that must be developed and used to ensure that changes to the process can be implemented without negatively affecting the line performance. Although basic, upfront training was done during the early stages of the kaizen program, operators must be trained how to act and operate in a standard work environment. The week following the kaizen event is the best time to train operators and supervisors on the fundamentals of their new line process.

Training

Operators are now on a learning curve, so this first week will present many challenges to the assembly line, as well as the company. I talked about this in Chapter 1, and also mentioned the fear of change chart (see Figure 13.1).

The chart is a generalized representation of certain business metrics used to measure performance in the company. Point 1 indicates the state of the company prior to kaizen events and process improvements. Point 3 indicates where the company needs to go in order to be competitive in the market. Point 2 is what occurs directly following change. Operators and supervisors must adjust to working in a much more structured environment, with rules and regulations. Waste has been removed and there are no buffers for inefficiencies. To ensure success of the assembly line, they must follow these rules very closely or productivity will decrease, quality will suffer, and daily volume requirements may not be met.

During the first week after the kaizen event, some operators and supervisors will rebel against the change and try to return to their old ways of working. Or, they will follow the new guidelines, but will need sufficient time to adjust. The best way to train these employees is right on the line,

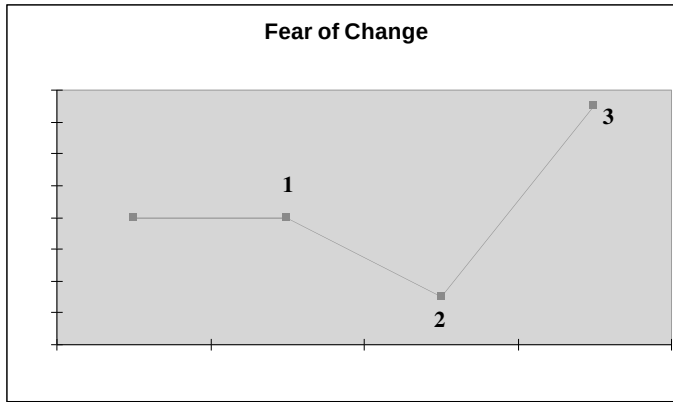


FIGURE 13.1
Fear of change chart.

while they are building product for the day. The original kaizen leader and the kaizen champion should conduct training on the following:

Single piece flow (push vs. pull)
Flexing
Effective hours
Tower light use
Two-bin system
Build levels

Single Piece Flow (Push vs. Pull)

During the kaizen event, the team removed the excess work in process (WIP) and implemented single piece flow. Single piece flow is quite self-explanatory, but the operators will need some assistance in understanding the concept. Single piece flow is the movement of products, units, and parts through the manufacturing process, one unit at a time. Single piece flow focuses the employee's effort on the process itself, rather than on performing nonvalue-added work, such as waiting and overprocessing.

Explain to the operators that they are to pull units into their workstations only when they are ready to start work (see Figure 13.2). Units should not pile up between workstations, creating wasted WIP, which will ultimately create quality and flow issues.

If operators complete their work early, they are not to push the unit into the next workstation. In a pull system, products are built only when requested by the downstream process or workstations. The last workstation in the assembly line pulls and drives the flow of single piece units, which is why the takt monitor in the last workstation is the best gauge of flow.

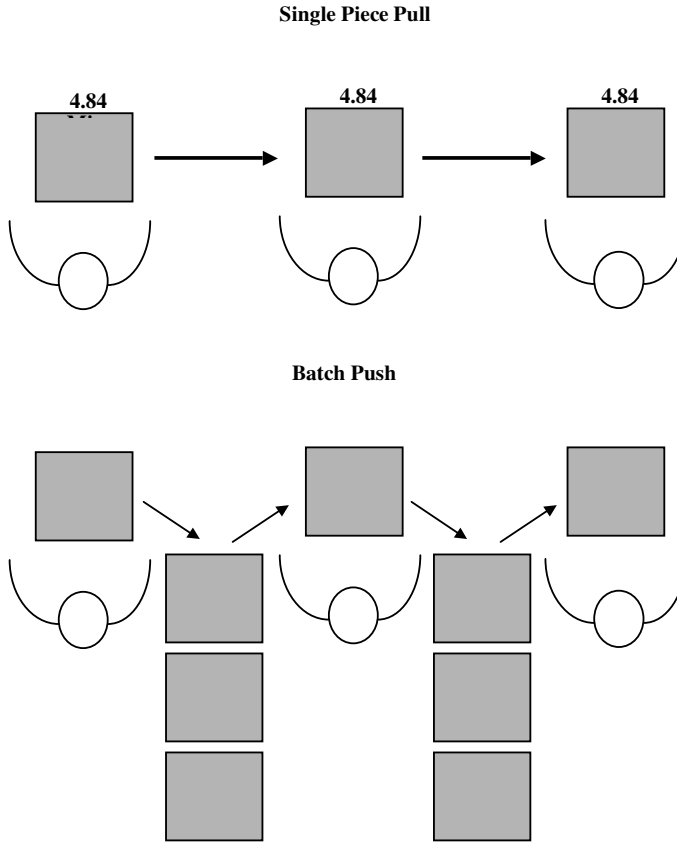


FIGURE 13.2
Batch push vs. single piece pull.

The same rule applies to material handlers. The assembly operator is pulling parts into his workstation as they are needed, and the empty bin or tower light is the request for more material. Material handlers should not deliver parts to the assembly line unless the proper signal has been given.

It is a safe practice to stop working for a few moments every so often. This prevents filling workstations with unnecessary WIP which will create bottlenecks. The whole assembly process is one big team, and the team should work together to keep the units flowing smoothly. To avoid pushing product, three simple rules should be followed:

1. Check your work. Rather than pushing it out and starting another, take the time to check your work one last time.
2. Do 5S. At the end of each day, before leaving, the operators are required to perform their 5S duties. Items need to be returned to their assigned locations and general clean up performed to get ready for the next day or shift. Rather than standing idle during a shift,

an operator can use the wait time for some general 5S. As an example, they can check to see if part bins are low or empty and turn on their yellow tower light. Additionally, operators can prepare for the arrival of the next unit.

3. Flexing. By the time an operator finishes his work, performs the quality checks, and does some minor cleanup, the other operators in the workstations around them will be ready to move their units. If there is a problem and they are unable to move within takt time, the operator who is waiting should move (flex) to help keep the line flowing.

Flexing

Operators on a line must be able to work in their own workstation, as well as in the workstations before and after theirs. This allows flexibility on the assembly line. Employees must be familiar with the work content and quality criteria in those three specific workstations. Each employee performs the work and quality criteria defined only by the work instructions in that operation. The designed work content and quality criteria at each operation do NOT change.

If an operator reaches for a unit to work on and there is no unit there, that employee moves in the direction of the pull, to work on a unit to supply the empty workstation. The employees are not told to do this, *it is an automatic response* to the absence of units flowing to their workstation. As rates decrease, operators should be removed and the production supervisor should use the rate card, the standard work sheets, and the operator placement map as a guide for the new setup.

The operators can help complete the units flowing to their workstation and then return to their station, or, the next operator down the line will move up and take position in the vacated workstation. Remember, ONLY do the work in that workstation. DO NOT bring work to another station. Taking work to another workstation will only make the hole bigger. The process and movement of employees is that simple: an employee moves in the direction of the pull.

A single piece pull process requires flexible employees. They are allowed to finish the work content in their station and move upstream or downstream to help keep the process moving. Operators simply move to the station creating the bottle neck. Sometimes, two employees will work on the same unit until the unit is completed, to help fill the vacant station. The line naturally will rebalance itself with flexible employees.

Effective Hours

From a planning perspective, calculating effective hours took place and was designed into the assembly line. However, operators need to understand the importance of effective hours and how to conduct themselves within it. This will be one of the challenges in changing the culture.

The old assembly line was filled with waste, allowing operators to work at whatever pace they chose. Operators could easily leave their workstation for bathroom breaks or for any other reason. They could also take their time returning from coffee or lunch breaks. In a single piece flow environment, this is unacceptable. Now that the waste has been significantly reduced, operators must work within takt time and follow the rules and regulations of the line. These are the rules:

1. If an operator needs to use the bathroom, they should turn on their yellow tower light. The production supervisor or a line lead can man the workstation while the operator is gone. This keeps the line moving and avoids disturbing takt time.
2. Operators must return to their workstations at the same time. Production supervisors cannot allow operators to filter back into their workstations one at a time. Promote a sense of teamwork and explain to the operators that working together is a necessary requirement.
3. Operators should understand the importance of takt time. By flexing to each others' workstations to help, they can ensure that the daily volume requirements are met and that overtime is avoided.

Tower Light Use

Tower lights serve one important purpose: communication. To ensure that operators can work within the established effective hours and do not leave their workstations, they need to be able to communicate effectively to others in the plant. Even so, use of the tower lights should not be abused. Tower lights are used as signals for communication, and false signals will make people react incorrectly. Operators should never turn on the red light unless there is a major problem occurring in the workstation.

Operators should use their yellow lights when signaling for material, or when they have a general question for their supervisor. The green light should always be on when things are under control.

From a management perspective, support staff should respond to the tower lights when needed. Never leave an operator waiting for a long period of time. Their issue should be addressed, to ensure their confidence in the system. The plant has to work as a team and react to the tower lights when they are not green.

Two-Bin System

A two-bin system is highly effective when used correctly. Any deviation from the system will become quickly noticeable. Operators and material handlers should work together to make sure that parts and other material are available. Once the first bin becomes empty, the assembly operator should turn on his yellow tower light to signal for a material handler. Operators should never

wait until both bins are empty, because material handlers support many operators and may be busy. The material handlers have sufficient time to respond to the lights because of the proper part quantities established by the kaizen team. Line operators should not panic when a material handler does not come to their workstation immediately. If an operator waits too long before signaling the material handler, bottlenecks in flow will occur.

Material handlers should remove the empty bin, add it to their material cart with the other bins, and turn off the tower light. They should return to the stock room and fill the bins, according to the bin label. Upon returning to the workstation, the material handler should take the bin that is being used and place it on top of the newly filled bin. This keeps parts flowing at a consistent pace. This also applies to material that has to be delivered by pallet jacks. The assembly operator should turn on their yellow light when a tote or pallet has run down, signaling the material handler to replenish it.

Material handlers should be considered the lifeline of the assembly workstations, and a significant contributor to the success of the line. Operators and material handlers should work together as one big team.

Build Levels

Operators building to build levels need training on the importance of not overbuilding and creating WIP. The build levels established by the kaizen team should be followed. The operators in work cells designed with build levels should pay close attention to the subassemblies as they are pulled for the main assembly area. Their job is to react to empty queues and build to appropriate quantities.

Main assembly operators should use their yellow tower lights when their levels of subassemblies are running low. Material handlers can go to the subassembly work cell and gather the necessary items. Once the subassemblies have been removed from the work cell, the subassembly operators can begin building again.

As you can see, it is important for operators, material handlers, and support staff to work as one big team. A waste-free manufacturing process has to have rules and regulations to ensure that the old way of working does not return. By doing so, you create an environment that is efficient and pleasant to work in. Over time, everyone will realize the benefits of working this way, and the whole process will become easier.

New Employee Training

The approach to training newly hired employees is now completely different. Many companies either do not have a training program, or do quick, insuf-

ficient training, so that employees can assume job responsibilities sooner. In reality, training is conducted in the same reactive manner as everything else in a crisis-managed environment. Now that the processes are highly organized and employees are operating under strict standard work, new employees cannot be rushed through training. The kaizen governing committee needs to create a comprehensive training program that not only teaches company policies, but trains new hires to understand the fundamental aspects of the product and process in which they will be involved. Training in a standard work environment should include the following elements:

- Product overview
- Lean basics
- Incentive and pay for skill training
- Mock line training

Product Overview

New employees should all attend at least one course on products manufacturing at the company. Depending on the amount of products, and the specific job requirements, more than one course may be necessary in the training program. Basic product knowledge is very important. Preliminary instruction on terminology, parts, part descriptions, part numbers, and how parts fit together will provide great benefit once they are actually placed on the assembly line. The appropriate training will allow them to better understand the work instructions and the quality responsibilities of the operators at the workstations.

Lean Basics

Training should be provided on 5S, seven wastes, standard work, two-bin and subassembly system, visual management, and flexing. All training should be conducted in a classroom setting, and should be required of all employees before they are placed on the production floor. An operator working in a highly organized area, with procedures and rules, requires a basic understanding of lean principles in order to be successful. Do not expect the operators to understand these principles at the level that the trainer or kaizen champion does. At least, not initially. After working on the line for a while, they will eventually see how it all works. There may be new hires that have worked in a lean environment before and these individuals are likely to understand a bit better. Of course, any job applicants who have a background in lean are highly desirable. Human resources should decide if a lean management background is a requirement for employment in manufacturing, or just a nice skill to have.

Incentive and Pay for Skill

During the interview process and after hiring, Human Resources should explain how the production floor works under a cross-functional matrix, and that incentives and pay increases are given for learning new operations. The more workstations or job processes an employee knows, the better asset he or she is to the company. The bigger the asset, the higher the pay. Knowledge is equal to money. After a new operator has been working for a while on the line, participation in a kaizen event should be a requirement. The more events an operator participates in, the more pay they can qualify for when it is time for a pay increase.

Mock Line Training

Hands-on training is the final stage of the training process. Before the new operator is placed on the line, he should spend a few days working on a mock training line. A mock line is an assembly line that looks and operates like a real assembly process, but is actually used only for training purposes. Training lines should mimic real production lines. New operators will be able to learn how to use the two-bin system and subassembly build levels. They can operate the tower lights for material replenishment, simulating a real need for part replenishment. Flexing can be practiced, and new operators can learn how to work within the effective hours and takt time. Work and quality instructions will be displayed in the same fashion as on the real assembly line, and operators will be taught what the icons and symbols mean. The mock assembly line is a valuable tool to prepare new operators for working on the production floor. It will reduce their learning curve and typically prevents the flow from slowing down once they are on the job.

It is best to design and construct a mock assembly line through a kaizen event, just like any other assembly process. Use an actual assembly process as a reference for the design. For example, if a mock assembly line were to be constructed for operators preparing to work on the electric bike line, I would recommend using the headlight feeder design as a reference.

Training of existing and new employees is important, not only for working on a lean assembly line, but to help reduce turnover and retain qualified operators. Using the pay for skill system encourages operators to learn more and become valuable resources for the company. The amount of money spent on good training is a solid investment that is well worth the cost. Well-trained employees will result in less absenteeism and less employee turnover, both of which are significant cost savings to any company. Train and develop your soldiers and reward them for learning more and performing better.

Accountability

This book has provided a lot of information about the responsibilities of the operators and material handlers. Their training and embracing of kaizen philosophies is critical to the success of the line. Certain important rules should be adhered to, such as remaining in their own workstations, and working within the effective hours and takt time. However, operators are not the only employees that need accountability. Management and engineers play an equally critical role and should be accountable when they make operators deviate from the standard protocol.

Even after all the upfront planning and training of management and engineers, these support figures will almost always try to push the envelope. Therefore, certain guidelines need to be established for all support staff.

Daily Guidelines

Sometimes it is difficult for a production supervisor to understand the 85% rule. In a volume-driven environment, production supervisors push their operators beyond realistic levels, requiring more and more product to be built. This is because they do not understand the capacity of their line or the abilities of their people. After implementation of standard work, 5S, visual management, and an employee cross-functional matrix, production supervisors must be sure to follow the guidelines in the standard workbook.

Manpower numbers have been set to support the various rates, and the manpower needs to be placed in the designated locations. Supervisors and managers cannot simply throw bodies at the process in order to get more output. The standard work will not allow for it. Operators are loaded with specific work content set to maintain takt time and quality. Adding operators without defined roles is highly unproductive, and will only create problems for the process. If a production supervisor reacts to problems in flow by adding more people, it shows that they were not monitoring the visual management well enough to be able to see the problem as it was approaching.

Operators should never be asked to work faster in order to make up for lost volume that occurred because of external circumstances. Working beyond an 85% pace will cause operators to make errors. Adjustments can be made to the effective hours, but operators should never be pushed to work faster. This just is not effective in a standard work process.

Ongoing Guidelines

Lean assembly lines are work content driven. Standard work sheets dictate design and control of the line. However, changes to product design occur all the time in manufacturing, in order to control costs and satisfy customers.

These engineering changes cannot be implemented with concentrated attention and effort, because changes to work content and parts affect everything. For example, adding a new option to a product will require changes in the build sequence. Changes in the build sequence require the evaluation of workstation loads and how the change will affect takt time and flow. Additional or new parts are required for the new design, and that requires additional part bins and labeling. New equipment and tools may need to be installed, and this changes the physical layout. If the part is large, parts racks and shelving may need to be modified. Work instructions and quality responsibilities will change and new documentation has to be created.

Making changes to the product requires upfront planning and implementation strategies. If the changes are small in nature, then it might only require changing a few bins out, making new labels, and adding tools. A process engineer can plan his week around this and prepare for the modifications. But, if the changes dramatically affect flow, takt time, and volume, then a kaizen event should be scheduled to make the change. Do not take engineering changes lightly. It is good to come up with a form and the appropriate sign-off for engineering changes; an Engineering Change Request (ECR) form, for example. This is appropriate for changes to the process, as well as changes to the product. Make sure this form includes changes to the two-bin material system, labeling, standard work sheets, and any other aspect of the workstation design.

Following the standards and procedures that are implemented during a kaizen event is, by far, the single, most important aspect of kaizen and lean. Never underestimate how quickly your operation can return to the state it was prior to the kaizen event. Although I have been part of many success stories, I also acknowledge a small handful of companies who were not able to maintain the program, or implement improvements. It is a waste of money, time, and business to let your newly designed lean processes fall apart. Develop a comprehensive training program and keep everyone accountable to sustaining the improvements. It benefits everyone.

Chapter Summary

- Results achieved from a kaizen event depend on the level of training and accountability instilled in the employees.
- Operators should understand the benefits of a single piece pull system.
- Operators need to learn to work with their material handlers and properly communicate through the use of their tower lights.
- Flexing between workstations will keep product flowing to takt time.

- A comprehensive new employee training program designed for lean manufacturing needs to be developed.
- Design and construct a mock training line for better hands-on training.
- Managers and engineers need to follow certain guidelines when attempting to make changes to the assembly line.

14

Moving Forward

What now? Your first successful kaizen event will feel great. This sense of accomplishment should be a great catalyst for future improvement efforts. Now is the time to get refocused and begin the next phase of improving the operations of the company. Kaizen should become a way of working, and continually improving upon what the kaizen team has done is the next step. It helps create a foundation for other improvement efforts that should be ongoing in the facility. This chapter will be devoted to giving suggestions for further improving the line after the kaizen and how this effort can continue into other areas.

More Kaizen

Kaizen and kaizen events do not end after one project. Kaizen is not a one-time thing. It is a fundamental approach to improvement and should continue through the life of the company. By the time the first kaizen event is done and the action items on the 30-day mandate have been assigned, it is about time for the next kaizen meeting.

The kaizen governing committee should review the results and plan the next event. Were there any problems with the event? What lessons were learned and how can the next team execute better? The kaizen program is in place to ensure that continuous improvement does not become a one-time occurrence. Before employees have an opportunity to cast a negative opinion about kaizen, another event has begun with a different team. Over time kaizen becomes a way of working and kaizen events are simply part of the organization's strategic purpose.

Kaizen Event Ideas

The premise of this book was designing and constructing a lean assembly line. However, kaizen events can be used for a variety of other things. Do not corner yourself into thinking that kaizen events are only for floor implementation ideas either. Remember, every kaizen event should be planned with the intention that it will help the overall success of the organization. Kaizen events can be one day long or one month long. As long as the kaizen event is scheduled with the purpose of continuous improvement, you can never fail.

The Second Pass Kaizen Event

As you know by now, kaizen never ends; so it is perfectly reasonable to schedule and conduct another kaizen event in the same area. After the new line has operated successfully for some time, other improvement ideas may come up that would warrant another event. For example, there is always room for waste reduction. In regard to the electric bike line, maybe there is a more efficient way to test the electric bike. Can the bike frame be installed easier onto the shipping pallet? Is there opportunity in the packaging station for better box installation? Can the subassembly work cell be redesigned and the finished subassemblies be placed closer to the workstation, eliminating the need for a material handler? The operators on the new line will more than likely find an opportunity to improve the process better, and their ideas should be reviewed by the kaizen governing committee.

Inventory Reduction Event

Reducing inventory in the factory is a major component part of any lean strategy. The amount of money and time that can be saved from inventory reduction is enormous. However, overall inventory reduction efforts can take time and requires the involvement of many different departments and suppliers. I highly recommend that an organization commit the resources and time to do this, but for the purposes of this book I will focus on inventory reduction within the assembly process.

During the designing of our electric bike line, I outlined the importance of creating part quantities that were used to decide how much material was placed in the workstations. Parts were identified by being either common or uncommon. Common parts quantities were set at 24 and uncommon parts were set at 12. Rather than having the kaizen team develop a comprehensive part replenishment report for material quantities, the team can come up with

new quantities based on physical size and time to assemble. An inventory reduction event can be conducted to look only at the parts and material in the line and refine its replenishment and presentation. The more inventory that can be reduced on the factory floor, the better. This kaizen event can be part of the company's overall inventory reduction efforts. As time goes on, more inventory reduction events can be planned in the stockroom and then eventually back to the supplier.

Line Removal Event

Floor space comes at a premium, and effectively utilizing that space is important. Assembly lines or other processes that have stopped running due to outdated products or loss of demand should be removed to make way for future products. The reason it is important to remove a line through a kaizen event is to ensure that it is done correctly. There could be bins, shelves, tools, fixtures, parts, or other items that can be used somewhere else.

This event should be planned and conducted as one big red tag project. Organize all the items on the line in categories and use red tags to keep track of what is being removed. The materials department should be involved so proper locations can be identified in the stock room. Should a "garage sale" be planned after the kaizen event to permanently remove the items from the factory? How are obsolete parts and material dispositioned?

A well-planned line removal event will enable the company to quickly and effectively dismantle a line and keep track of what happens to the items. It will prevent poor use of storage space and allow the company to reuse items for future improvement efforts.

5S Event

In this book, 5S implementation was part of the overall plan for the kaizen event. To sustain standard work and visual management, 5S has to be part of the implementation efforts. This does not mean that a 5S event cannot be scheduled on its own. Not every area of the plant will use single piece flow, nor is every area an assembly process. Cleanliness and organization is important in every part of factory machine shops, and fabrication departments can benefit greatly from 5S. If your company uses a design laboratory to test new products, it should be organized as well. The 5S concept would be good for a maintenance department, and in the shipping and receiving departments. It should be a company goal to remove all unnecessary items and have a location for everything in the factory. If an organization conducted

just 5S events every month, there would be vast improvements to productivity, quality, floor space, and throughput as well.

Line Design Event

Sometimes the area selected for a kaizen event is so complex that it requires the dedicated effort of a design team to come up with implementation strategies. The design team is usually the implementation team once the event is conducted. I have lead design kaizen teams in the past, and they proved to be very beneficial. One particular plant was planning on consolidating two lines into one and adding a new product to the mix. The kaizen governing committee felt that a design team was needed to prepare for such a huge project. It was scheduled like any other event with the team being selected two weeks prior to the event. All planning supplies were ordered, food was provided, and a conference room was reserved for a week. It was concluded that the design event would significantly improve the implementation efforts and help the team avoid major obstacles.

Material Handling Event

Material handlers need standard work as well. Their job responsibilities and tasks throughout the day need clear definitions. Material handlers can become very inefficient in their work if they do not adhere to any standard work. These types of events have to be very well planned because material handlers often are allowed to operate on their own. Essentially, they generally work with as much freedom as they want making as many trips back and forth carrying varying quantities of parts. Going from no structure to standard work is difficult, but they need defined roles.

Similar to the early stages of assembler's standard work, material handlers need to be timed and their movements analyzed for waste. Waste takes on a little different meaning in regard to material handlers. Their job requires them to walk a tremendous distance. An ideal situation is to have external suppliers deliver parts directly to the workstations at set times with established quantities. Even so, many manufacturers still use material handlers, and the amount of walking they perform should be reduced.

The kaizen champion should follow the material handlers around and document their movement. Time studies should be performed on this movement, tracking how long it takes to walk to the stockroom from the line and back. How much time do they spend looking for parts and filling parts bins for the workstations? Is the stockroom poorly designed and their material

spread out over a long distance? Do the material handlers supply multiple workstations on the line? Do they have other responsibilities like removing empty pallets and boxes? All of these items need to be recorded on a time and motion study sheet and analyzed for continuous improvement ideas. Time studies should also be done on how much time is required to work the two-bin system when bins are switched in and out of the workstation.

Material handlers should have specified routes and workstations that they are responsible to service. In regard to the electric bike line, workstation 10 and workstation 1 should not have the same material handler: the distance is too great. An analysis of the quantities of parts in the bins and the replenishment time is needed to better create efficient routes.

A material handling event and an inventory reduction event could be conducted at the same time. The goals of each event team would complement each other. The frequency with which material handlers return to the line with parts and material is dictated by the replenishment times and quantities of parts stored in the workstation. Low quantities of line parts will require more walking, but reduce inventory. Higher levels of parts allows for less frequent returns from the material handler, but increase inventory. Also, a material handler should not be required to handle too many parts at one time for safety reasons.

One of the best approaches to material handling is to implement midpoint storage in the facility. A small supply of material placed between the line and the stockroom can be used by material handlers to replenish parts bins or palletized material. The kaizen team needs to establish the quantity requirements for the workstation and for this storage area near the line. This does not necessarily reduce floor space; the space needed for the parts in the stockroom would be used closer to the line. Larger quantities of material are still stored in the stock room, but the parts and material are broken down into smaller quantities and delivered to the midstorage points around the line. This keeps forklifts out of the assembly area as the material handler would then supply the line from the midpoint storage. A pallet jack can be used to deliver palletized parts to the workstation if needed. Figure 14.1 illustrates the use of a midpoint storage.

A material handling event can reveal a lot about how inventory is stored in the stockroom. In conjunction with an inventory reduction event, or through multiple events, a material handling event can create an efficient material handling system and significantly reduce the amount of parts and material in the factory.

Mistakeproofing

Human error is a fact of life. Even if machines and equipment are set perfectly, mistakes can be made. During the electric bike kaizen event, quality

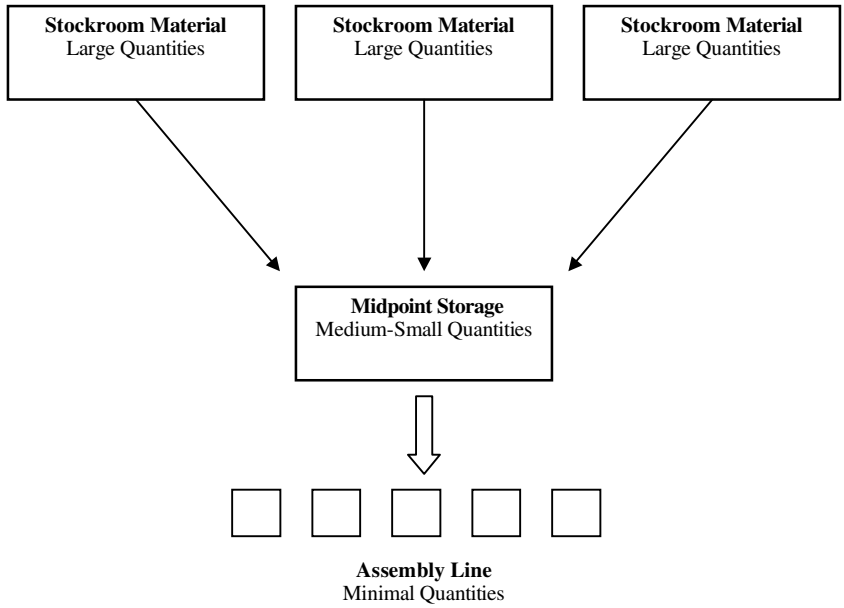


FIGURE 14.1
Midpoint storage.

at the source was implemented requiring operators to do quick incoming and outgoing checks in their workstations. This is called source inspection because it is about catching errors before they turn into defects. The electric bike went through a series of tests and inspections prior to packaging. This type of inspection and testing is called *judgment inspection* as the test operator is comparing the final product to a specification. If the electric bike does not pass the tests, it is rejected. Part of the company's continuous improvement efforts after the kaizen event should be in the introduction of error mistakeproofing. Unless a kaizen event is specially done with the intention of mistakeproofing a process, the team may not have adequate time to design and implement innovative mistakeproofing techniques.

Mistakeproofing is a methodical approach to ensuring that quality is built into the manufacturing process. Defect prevention is designed into the system by eliminating the cause. Since defects are caused by error, eliminating the error will result in higher quality.

Examples of mistakeproofing include:

Product design

Eliminating picking errors

Use of fixtures or jigs

Visual indicators

Product Design

As manufacturers increase the number of products available and the selection of options in a mixed model assembly line, part confusion increases significantly. Mixed model assembly lines generally contain more parts than single model lines. Product designs should be standardized as closely as possible to use similar hardware and parts. The more parts that are eliminated from a mixed model assembly line, the less chance that an operator will select the wrong part. Products need to be designed that make it difficult to install the wrong part.

Eliminating Picking Errors

Workstations should be designed to help reduce an operator's chance of installing the wrong part. For instance, securing a part that will vibrate during the product's use with the wrong hardware may result in the part coming loose earlier in its life cycle. A kaizen team or group of engineers can come up with creative ways to reduce or eliminate picking errors during assembly. As I mentioned in Chapter 10, hardware should not be placed in the workstation right next to another similar type of hardware to avoid spillover problems. Never place hardware underneath a conveyor or another type of open work area. Otherwise, hardware could fall below the conveyor into the incorrect storage container.

Material handlers should be the only employees that are allowed to remove parts from the stockroom. If there is a breakdown in the two-bin material system and an operator does not have the parts they need, they should not leave their workstation to go looking for their missing items. Material handlers are usually not allowed to assembly products, so operators should not be allowed retrieve their own parts.

Use of Fixtures or Jigs

Manufacturing engineers should look at the new process and find ways to implement devices that will further improve errorproofing. Designing and fabricating fixture and jigs for workstations may take some time. Again, preplanning a mistakeproofing event may be needed to expedite the process.

There are countless approaches to fixtures. Guide pins of different sizes ensure the correct movement of parts. Plates or templates can be used over a part that has multiple holes, outlining where certain hardware goes. The use of fixtures and jigs can also improve productivity. For instance, the next kaizen event after the electric bike line could be a mistakeproofing event as a second pass. Mistakeproofing ideas can be implemented to improve quality, but the use of fixtures and jigs could make assembly easier and safer, hence eliminating waste.

Visual Indicators

The use of visual indicators can help reduce the variability within a process and provide clear direction on what is going right or wrong. Looking back at the electric bike line, there were a lot of visual references implemented that helped eliminate confusion or reinforced the use of a process. Most of these visual management concepts were outlined in Chapter 4, but I will review some of them to better explain this section.

To avoid picking errors, the labels on the part bins were colored coded. Each assembly line or process should be given a color providing distinction between each other. If line A uses green labels and the part bin is placed on line C that uses yellow labels, it is quickly identified as being in the wrong location. An operator standing in the workstation or a supervisor 50 ft away knows that a part bin is in the wrong location.

All storage racks and workbenches should be clearly identified with a designation. Labels on the bins describe what parts belong in there and where on the factory floor it goes. If a workstation has more than one storage rack, then they can be labeled A1, A2, and A3, appropriately. The parts label should outline which of the three racks it is supposed to go to. A step further, the three storage racks can supply parts for three different models labeled accordingly. For example, the parts for Model 10 could go in rack A1, Model 20 parts could go in A2, and Model 30 parts could go in A3.

Other forms of visual indicators are visual switches that show the presence of a wrong part. Devices that count the number of parts being produced could indicate when something is out of sequence. Visual alarms or warning signals could go off, notifying the operator that a defect or an error has been caused.

The more visual a factory floor is, the better a company is to react to problems and come up with continuous improvement ideas. Just as engineers make mistakes in writing instructions, accountants can add or subtract incorrectly, a receiving person can store material in the wrong area, or an operator can install the wrong part. Human error is going to happen; it is unavoidable.

However, kaizen teams can be put together to address these issues and come up with ideas to reduce or eliminate the opportunity for mistakes.

Ergonomic Evaluations

Ergonomic approaches to manufacturing usually focus on postinjury claim damage control. Damage control is not proactive, and ergonomic evaluations of the line should be done in a manner that is not reactive. By using a risk identification and injury prevention approach, companies can create manufacturing processes that are safer for the operators, but can improve productivity and quality as well. After the new assembly line has been operating for

about a month, manufacturing engineers should begin ergonomic assessments of the line and find ways to improve the process even more.

This proactive approach should be based on quantifiable data that provides the opportunity to identify risks. Identifying high-risk workstations and work areas and coming up with ways to reduce injury before it happens is the best approach. I recommend using point driven analysis that assigns a level of risk to a certain movement.

Certain body positions, like a head looking up, twisting without the ability to move the feet, bending forward to pick parts, or uncomfortable wrist movements due to an inefficient tool, should be assigned a risk value. Every movement has an ideal state and any deviation from that ideal state is rated accordingly. As more and more movements fall outside of this parameter, it is more likely that an injury will occur. Engineers and managers can use this type of analysis to be proactive and create workstations that allow operators to stay in the ideal position.

Chapter Summary

- Start scheduling monthly kaizen events.
- Conduct a second pass kaizen event to further refine an area.
- Reduce inventory levels in the assembly processes for greater space and cost savings.
- Use kaizen events to effectively remove a line no longer in operation.
- Line design events are great for reducing possible obstacles on a line that is very complex. This type of event will allow the implementation team to be even more successful.
- Conduct a material handling event to create standard work for material handlers.
- Use a mistakeproofing event to ensure that quality is built into the manufacturing process.
- Use a point based analysis approach to identify risk within the workstations.

15

Coin Dispenser Manufacturer Success Story

I have been using the kaizen approach to implementing lean for some time now. It has proven to be very successful for companies I worked for, as well as those for whom I was a consultant. Results varied from one company to the next, but one particular company realized the biggest impact: a manufacturer of coin dispensers, located in South Carolina.

This company had a variety of production problems, all resulting from poor assembly line and workstation design. The plant consisted of five manual assembly lines, which were stretching across the length of the plant due to excessive amounts of work in process (WIP). There was no sign of 5S, and work instructions for the entire assembly line were kept in a folder beneath one of the workbenches.

Operators were allowed to wander the floor, or stand around doing nothing, when parts or units were not readily available for use, which was common. The ratio of permanent employees to temporary employees was 3/1, and there seemed to be a higher skill set among the temporary employees. Waste existed at every level and productivity was at an all-time low, hovering around 60%. This company needed immediate assistance. They were in trouble, and, to make matters worse, they were preparing to launch a new product and needed floor space for a new assembly line.

At first, management was convinced that the solution was to add on to the facility to provide more room for their current processes and to accommodate the new product. For years, they had operated in a reactive solutions mode, never fixing anything permanently. After hiring a few lean-oriented engineers, they realized the need for a program that would implement 5S, standard work, and visual management. Here is their success story.

There was a lot of work to do at this company. I had convinced them that they needed to create a comprehensive kaizen program to ensure that the changes made would be significant and would impact the company financially. In the past, they had attempted other methods of implementation, but without being able to sustain the changes.

Developing the kaizen program was easy. The engineering manager had previously worked within a kaizen program that was somewhat similar to the program described in this book. We identified the six kaizen governing committee members, which included the engineering manager, the plant

manager, the purchasing manager, the production manager, the human resources manager, and myself (temporarily). I scheduled a meeting to formulate some ideas and start creating the key elements of the program. The committee asked me to take on the role of kaizen champion until I was able to select an individual to step into the role after my consulting services were complete.

As the temporary kaizen champion, I established the kaizen event tracking system and the various methods of communication, which included the suggestion box, the newsletter, and the kaizen event communication board. Once established, the human resources manager later assumed responsibility for updating the newsletter and retrieving suggestions from the suggestion box. Since I was the kaizen champion, I had responsibility for most of the action items. After one week, which was spent working on the tracking system, the tool supply box, the newsletter, and the kaizen event communication board, I scheduled the first official kaizen governing committee meeting.

This company had existing problems with holding structured meetings and ensuring attendance. Used to operating in crisis mode, with high absenteeism, I wasn't positive that everyone would show up, but, fortunately, they did; and they were all on time. I displayed the kaizen tracking work sheet that I had created in Microsoft Excel™, and we started working. The group was very enthusiastic about this new venture.

There were five assembly lines in the factory. The company had not conducted any value stream mapping or current state analysis, so I suggested that the group select the line with the worst productivity and quality. The group chose their A10 line, which was used to assemble their oldest product model, and we scheduled the first kaizen event to refine that line.

Our two preplanning items were to conduct time studies on the work content of the product, and to establish a more efficient work sequence. The committee chose me to be the team leader, and team members were selected and assigned to the kaizen event. The upper managers on the committee were responsible for ensuring that team members would be in the plant the week of the kaizen event. It was an effective, inaugural kaizen meeting and we all left satisfied with the outcome. The anticipated results for line A10 were:

Productivity: 20% increase

Floor space: 30% reduction

Workstation requirements: 35% reduction

WIP (work in process): 50% reduction

Throughput time: 60% reduction

The committee decided to assign an assistant to help me collect the time studies and come up with suggestions on the work sequence. The assistant had experience working on the A10 line, so his input was very valuable.

We completed the time studies in about three weeks. There were some initial setbacks, because not all of the products were scheduled for production on the A10 line during this time period. The company worked on a build-to-order basis, but they scheduled every product that was built on the A10 line in the interim so we could capture all the time study information. Therefore, we had data on all models. Finished units were simply held in inventory for future orders.

I had anticipated that the new A10 line would be short, because many of the unused items in the current line were from an outdated product that was no longer available. I knew that there was going to be significant floor space savings. At the time, the company did not have CAD software that I could use to design my concepts of the new line. Of course, the team would decide the final layout, but it would have been beneficial to have a general idea of our approach.

One week prior to the event, my assistant and I took the time studies, the design output, and the effective hours and established new workstation requirements. The A10 line was to be designed to build 15 units a day on one shift. The effective hours were determined to be 420 min, or 7 hr. Unfortunately, takt time was approximately 28 min, so we knew we had a big job ahead of us. Effective station design was critical to reduce the boredom that typically accompanies lengthy takt times. On Friday, the week prior to the event, my assistant and I had prepared the standard work sheets.

The event had been scheduled to take place from 12:00 p.m. to 8:00 p.m. so we would not disturb the operators while they were working. This schedule also allowed us to have the whole plant to ourselves. The managers on the kaizen governing committee confirmed that all team members would be in attendance. We were ready to begin.

A10 Line Kaizen Event, Kaizen Team 1

Day One

At 12:00 p.m. on Monday, the team met in our designated war room, where we would be living for the next four days. After everyone had settled in, I began the kickoff meeting. Using the board, I listed all the action items that had to be completed before we left for the day. I made sure that the team understood that regardless of where we were in the process, the assembly line must be fully operational the following day. I indicated that the operators were aware that the line would be pieced together slowly over the week, and that there might be some moments of confusion. I reinforced that the team's regular job responsibilities had been temporarily reassigned, and that I expected 100% participation. The team was enthusiastic, and ready to begin, so we began discussing the action items.

There were only seven members on the team, and we needed to complete two tasks by the designated dinner break. I divided the team into two small groups for the first half of the night. The two tasks were to conduct the first S (sorting) of 5S, and to review the standard work sheets. The best method of identifying unnecessary items in a workstation is to follow the standard work sheet because it lists the minimum requirements to perform the work. However, the operators on the A10 line already knew what tools, benches, equipment, and parts were no longer needed, because they had been used on product that was no longer built.

I assigned three individuals to the 5S task. They were to go to the A10 line, remove all items that had been used to build old products, red tag all these items, and place them in our designated red tag area. The remaining four team members worked with me reviewing the standard work sheets, checking for errors in the work content, part requirements, and tool requirements. We also tried to identify any waste reduction opportunities. Prior to the event, I had formulated some ideas about a new design that would reduce waste. In the current state, most of the parts on the A10 line were located far away from the operators, and there were a large number of coin dispensers situated between stations. By implementing single piece flow and placing the parts at the point of use, I would improve productivity almost instantly. However, rather than put forth my ideas and run with them, I wanted the team to focus on ways to refine the design even further.

I had been analyzing the standard work sheets for over a week, so I allowed the team to work on their own and come up with ideas. Periodically, I checked on the other team members who were removing items from the line. They were crawling around the assembly line pulling out air tools, workbenches, computers, parts, part bins, and so forth. I could see they were filling out the red tag forms and keeping track of what was being removed. I took a few "before" pictures of the line for the closeout presentation, which was scheduled to take place on Friday.

Everything seemed to be progressing well. The group reviewing the standard work sheets could not identify any major errors in the work content. There were a few parts missing from the sheets, but the group concluded that they were mostly complete.

The company ordered lunch for everyone and the team gathered in the cafeteria to eat. Everyone felt positive about the day and I felt confident that the action items for the day would get completed.

After lunch, we had our midday meeting. Then the red tag team went back onto the floor and continued their sorting efforts. Since the standard work sheets were complete, I asked the remaining team members to use the sheets to verify a few of the time studies. I was pretty confident that the data was accurate, but I wanted them to be more actively involved. By the end of the night, the red tag team had accumulated a mountain of workbenches, tools, documentation, chairs, racks, shelves, and parts that were no longer needed on the assembly line. There were at least 20 workbenches in the pile. I walked to the front office and invited the department managers to come

out and see the pile of garbage. They were shocked. The plant manager stood there, as if hypnotized by the mess. He said, " I can't believe we were working under so much waste." The finance manager was shocked by the amount of money that had been spent on unnecessary items.

The team met in the break out room to discuss our progress. We had completed all the action items for the day and were happy that the project was on schedule. I listed the items to be addressed the next day on the conference room white board. The team was ready to begin the first phase of line construction. I explained to the team that we were going to refer to the standard work sheets and slowly piece together the new assembly line.

Day Two

After arriving at the plant on day two, I was informed that the production manager wanted the operators off the kaizen team and back on the line. Since the team had removed a significant amount of stuff, he was worried that the line would struggle to make the day's output. I met with the production manager and the plant manager to discuss the situation. The plant manager understood the importance of not pulling team members from the kaizen event, and assured the production manager that the kaizen team would help as needed.

With that issue solved, I returned to the team and explained that two team members would work with the operators for the first hour or two, in order to address any issues that might arise. As a veteran kaizen champion, I am aware of the team's responsibility to ensure that operators can still perform their work while the event takes place.

Two team members went to the floor to assist the operators, and the rest of us took the standard work sheets and the kaizen event supply box and got to work. The new A10 line would consist of four main assembly workstations and two subassembly work cells. Although the team's efforts on day one had opened a tremendous amount of floor space, the space we had to work with was still very narrow. I would have preferred to install feeder lines or other point of use work cells, but there was simply no room.

The team decided that the two subassembly work cells would be placed near the beginning of the line and we would establish the appropriate build quantities and signals for replenishment. As mentioned previously, the company did not have any type of CAD software, so we had to use our own common sense and knowledge about placement of the line. The team went over a few ideas and decided on the best option based on the allocated space (see Figure 15.1).

The coin dispensers are built on a pallet that is moved by a pallet jack. I tried to convince management to invest in some automation for this line, but, at that time, they felt the cost was too high. However, without a conveyor, the operators could walk in between workstations as needed. The coin dispensers that were produced on this line came with a lot of options

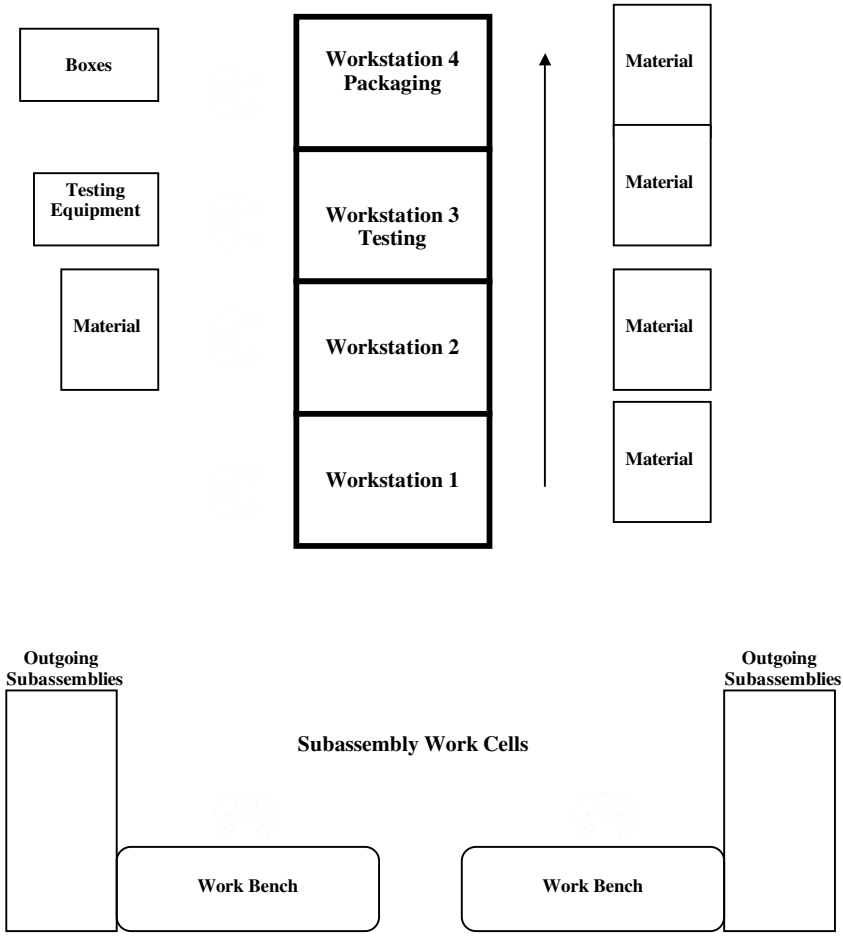


FIGURE 15.1
A10 line layout.

so there were multiple parts. There was simply not enough room on one side for material presentation, so we had to use both sides. The team made some measurements on the floor using the expansion joints in the floor for reference. A chalk outline was made to represent where items would go and then we double checked the layout. After everything was accounted for, the team started to tape the floor for designations.

After finalizing the location of the assembly line, I had the team place all items on the line that required network wiring or hookups for compressed air or electricity. I wanted the maintenance department to do the required installations before the end of the night, so the testing equipment and the air tools would functioning properly the following day. The team stayed focused and got most of the items into place. I had initially planned for two nights of line construction, and it appeared that the team would complete

the work in that time frame. Everyone left that evening confident that the next day would go as smoothly as day two.

Day Three

The team gathered in the break out room to review the final action items needing completion, in order to finish the construction. Our main goal for the evening was to have all the necessary items in position, so maintenance could begin their wiring and cabling. The team was divided into two groups: the first group was responsible for placing the items in the correct positions on the line, the second group was responsible for laying floor tape and other designations.

At this stage of the project, I knew the importance of keeping the team occupied and fully engaged. With the team working efficiently, I was able to break away and provide a brief status report to the plant and engineering managers. I reported that the event was on schedule and that we would be able to wrap up the visual management portion the following day.

Although there was one more day left to work, the assembly line was coming together nicely, and, as the night progressed, the team began to feel a real sense of accomplishment. I had to let them know that not all kaizen events run as smoothly as this one. I told them that their progress was a direct result of the company's commitment to the program, the planning done by the kaizen governing committee, and the effective execution of the kaizen team. It was important to recognize that the entire factory had worked as a team to ensure the success of this inaugural event.

At approximately 7 p.m., the team assembled in the break out room for the end of night closure. All the items had been properly placed and yellow floor tape secured the items to their location on the floor. Maintenance had decided to work a bit longer to ensure that the appropriate items were hooked up and functioning properly. I went over the action items for day four, which was to be dedicated to the implementation of visual signals and other items of visual management, which would help the new line run efficiently.

Day Four

I decided to arrive early that afternoon, in order to watch the operators work in their new environment. The new line was almost complete, and I felt compelled to get some feedback. Of course, the operators showed a bit of resistance, but I realized this was normal at the beginning of the learning curve. Some operators hated the new environment, stating that it would never work. Others were excited about the kaizen team finishing their work, and were anxious to see what the final results would be. I met with the production supervisor and we walked down the line and into the work cells. He was pretty confident that the new line would be effective, and would

produce the required volume. However, like most production supervisors, his main concerns were avoiding overtime and meeting the numbers. He had some background in lean manufacturing, and realized that the operators needed time for adjustment.

The team arrived for the last official day of the event, knowing that Friday was the closeout presentation. I briefed them on my conversations with the operators and the production supervisors. The operators on our team said that they were very happy with the way we had designed the new line. They assured the team that they would drive the change once they returned to their workstations after the kaizen event. Satisfied, I went over the action items for day four:

Implement the two-bin system and make the appropriate labels.

Establish the build quantities for subassemblies and make the appropriate labels.

Place floor labels on items that are not in the workstation shelves.

Install the tower lights.

Install the takt monitor.

Create the production control board.

Place a flip chart and easel on the line for operator feedback.

Install workstation signs.

Install the standard work sheets into the workstations.

Conduct a final cleanup of the line.

I allowed the team members to volunteer for the items they wished to work on. While they were making their decisions, I went to the supply room and retrieved the laminator, laminating sheets, and my laptop computer, so all the label making could be done in one room. Since I had to begin working on my closeout presentation, I appointed one member of the team to be the temporary leader, just to ensure that the team stayed focused. I spent the majority of the afternoon taking pictures and documenting the information I needed to make the presentation. Periodically, I checked with the team to see how they were progressing. The team appeared busy and on schedule, so I returned to my presentation.

The plant and engineering managers came out to the floor around 5:30 p.m. They were preparing to leave for the evening and wanted an update. I invited them for a walk through so I could better explain the design. Both of them were happy with what the team had done. Since they were also members of the kaizen governing committee, they knew that the team had taken into account the important attributes of assembly line design (i.e., effective hours, volume, takt time, the 85% rule, and time studies). They appeared to be satisfied with everything that had been accomplished. I did caution them that success of the line depended on the production manager's

ability to keep operators and supervisors accountable for adhering to procedures and rules that had been implemented. Any deviation from standard work or not reacting to the visual signals would result in lost volume and poor quality.

We completed day four activities around 8:30 p.m. The assembly line was complete. Of course, there would be a 30-day mandate containing various actions items requiring completion, but the line could operate to design capacity. The team took a walk through the line admiring their hard work and creativity. I congratulated the team on a job well done and sent everyone home, telling them to sleep in, but be there in time for the presentation, which was schedule for 11:00 a.m.

Day Five Closeout

I arrived at the plant around 10:00 a.m. in order to finalize my presentation and set up the necessary equipment. Team members began to arrive, and at 10:45 a.m., employees started to filter into the conference room. The plant manager thanked me for my services and appeared excited about the presentation. I explained to him that all the thanks should go to the team, as they did most of the hard work. Everyone sat down and I started the presentation. Table 15.1 shows the results of the event and Table 15.2 compares the estimated results to the actual results.

TABLE 15.1

Results

Item	Before	After	Improvement
Floor space	3580 ft^2	1890 ft^2	48%
Workstations	15	6	60%
WIP	22 units	6 units	73%
Travel distance	120 ft	25 ft	80%
Throughput time	8 hr	2 hr	75%
Scrap/month	$12,000	$1,200	90%
Productivity	60%	91%	36%

TABLE 15.2

Estimated vs. Actual

Item	Estimated	Actual
Productivity improvement	20%	36%
Floor space reduction	30%	48%
Workstation reduction	35%	60%
WIP	50%	73%
Throughput improvement	60%	75%

The results in the tables were documented after the first 30 days of operation. Over the course of a year, this equated to an annual savings of approximately $400,000 through the reduction of waste, WIP, and workstation elimination. Additionally, the purchasing department had revised their process of ordering material, to align with the plant's reduction in product models. This first kaizen event was considered a success and it prompted the vice president of global operations to visit the facility. It took about two weeks for the operators to become fully comfortable with the new line and the new standards. After just two short weeks, they became believers in kaizen, kaizen events, and the company's dedication to making the organization successful.

Six Months Later

I stayed in contact with the plant manager and the newly appointed kaizen champion. We had a few conference calls as questions arose after implementation. My intention was to help the company kick off their kaizen program and get them thinking in continuous improvement mode. Soon, the calls became less and less, and I started to believe that they had fully embraced the new program. About six months after the first kaizen event, I visited the facility to see if they had continued what we had all started on the A10 line.

The kaizen program was alive and well. The company had conducted four kaizen events, and was scheduling one per month. Employee turnover had dropped significantly. The space opened up from the first kaizen event was used to construct an assembly line for next year's new product, eliminating a need to expand the plant.

The plant manager asked me to attend their next monthly kaizen meeting to see if they were following the rules that we had initially established. Everyone was in attendance and the kaizen governing committee was clearly engaged in the meeting, as they scheduled events and selected team members.

I was taken on a tour of the plant floor to see the areas that had been altered during kaizen events. The company had redesigned two more assembly lines since I left. The lines were much more organized and visible. Workstations were set up for standard work and there was no WIP other than that in single piece flow. I could see tower lights, takt monitors, and production control boards. While observing one of their lines, I told the plant manager, "If I was a potential customer, I would be doing business with you soon." Table 15.3 and Table 15.4 show the results of the two lines.

The plant manager did indicate that "feet dragging" existed in some aspects of the program. The employee cross-functional matrix was taking a long time to complete. It was one of the items on their 30-day mandate that never got done. After two months of waiting, the kaizen governing committee decided to have a kaizen event and dedicate a team to completing the matrix.

The plant manager explained that they knew that they could not reap the financial rewards of the all the work they had done unless this cross-func-

TABLE 15.3

B11 Line Results

Item	Before	After	Improvement
Floor space	3200 ft²	2150 ft²	33%
Workstations	22	17	23%
WIP	30 units	17 units	44%
Travel distance	120 ft	85 ft	30%
Throughput time	8 hr	4 hr	50%
Scrap/month	$22,000	$8,900	26%
Productivity	72%	89%	20%

TABLE 15.4

D31 Line Results

Item	Before	After	Improvement
Floor space	2865 ft²	1950 ft²	32%
Workstations	18	14	32%
WIP	23 units	14 units	40%
Travel distance	90 ft	65 ft	28%
Throughput time	7 hr	4 hr	43%
Scrap/month	$10,000	$3,200	68%
Productivity	70%	86%	19%

tional matrix was complete. I could not agree more. The fourth event was to set up the assembly line for a new product.

I was interested in how these changes had impacted the company financially. The plant manager invited me to a working lunch, so that he could explain what had taken place during the past six months.

The types of results shown in these tables are common when a company is dedicated to change and the continuous improvement of their operation. Their hard work and their investment of only $10,000 to implement the kaizen program and hold kaizen events, resulted in a cost savings of nearly $1.8 million at the end of the year.

I stay in contact with this manufacturer and they continue to conduct kaizen events every month. New employees (hourly and salary) are required to have a background in lean and kaizen, and they must attend a series of training exercises in 5S, the seven wastes, standard work, and visual management. The company has stayed dedicated to creating a culture of change agents.

Final Thoughts

Kaizen has to become a way of life, and I hope this book has provided not only a reason for it but also a means to get there. It is important to remember that the implementation of lean philosophies has to be tailored to fit the organization's needs. Even with new technologies and innovations to manufacturing, manual assembly will remain the most common form of production for many years. With the ever-changing global economy, increasing competition, and customer expectations, manufacturers have to be in a continuous improvement mode to survive in the long term.

This change has to come from top management in the company. Making kaizen an organizational policy rather than a grand new idea is the best way to ensure that improvements are made and sustained. Good luck to you.

Glossary

85% Rule A workload concept of loading operators to 85% of takt time to allow for a more efficient and safe work pace that ensures better quality work and reduced stress on the assembler.

Batch Processing The inefficient movement of identical parts or products through a manufacturing process in large quantities all at the same time.

Continuous Improvement A methodical approach to continually changing and adjusting business and manufacturing processes to satisfy changes in customers' expectations through the elimination of nonvalue-added activities.

Cycle Time The time required to complete the tasks in a workstation or work process from start to finish.

Defect A product or part that does not meet the customer, company, or industry standard due to the inability of the company to catch and fix an error in the business or manufacturing process.

Effective Hours A concept associated with the amount of time operators actually spend building product on an assembly line or other manufacturing process. Calculated by subtracting the time for morning meetings, breaks, lunch, and cleanup.

Employee Cross-Functional Matrix A management tool used to train and monitor operator's skill level within an assembly line or other manufacturing process. There are three skill levels: trained, certified, and certified to train.

Ergonomics Sometimes called *human factor*, ergonomics is a scientific approach at analyzing the interaction between the human body and its environment. In a manufacturing process, it is the activities related to postures, repetitive movements, workplace layout, and human health and safety.

External Work Work performed in a workstation while other activities are going on. Does not require the full attention of the operator. For example, an automated saw my be cutting material while the operator performs measurements on previously cut parts.

Feeder Line An independent assembly process that flows into a consuming operation or main assembly line workstation. Feeder lines

are usually designed to takt time to ensure single piece flow. See *takt time* and *single piece flow.*

Flexing The movement of operators within an assembly process in the absence of a unit in the workstation in order to keep the line moving to takt time. Flexing is an automatic response to alleviate bottlenecks in the process.

Internal Work Work performed in a workstation that requires 100 percent operator participation (e.g., an operator using a manually operated saw).

Kaizen Japanese word for continuous improvement that encompasses the idea of employee participation and promotes a process-oriented culture.

Kaizen Champion An employee who is dedicated 100 percent to kaizen and to driving the continuous improvement efforts within the organization.

Kaizen Event A preplanned, scheduled process improvement project intended to implement lean manufacturing principles. Kaizen events are planned four weeks in advance to ensure 100 percent participation of team members and achievement of the event goals.

Kaizen Event Communication Board A visual aid used to communicate kaizen event information about teams, schedules, work areas, and team goals. Displayed near break rooms or facility entrances.

Kaizen Event Suggestion Box Used for collecting employee recommendations on future kaizen events.

Kaizen Event Tracking Worksheet A spreadsheet used by the kaizen governing committee to plan and track all kaizen events in the organization to ensure completion of all kaizen-related activities. See *kaizen governing committee.*

Kaizen Governing Committee A group of upper managers who oversee all kaizen event activities in the company. The committee, lead by the kaizen champion, meets once a month.

Kaizen Team A dedicated team of employees selected to participate in a kaizen event. Team members are selected two weeks prior to an event, and their usual day-to-day responsibilities will be given to someone else during that time**.**

Lead Time The time it takes to complete a task or activity from beginning to end.

Material Handler An employee who is responsible for delivering parts and material to a workstation or process, thereby allowing an assembler to concentrate on building product.

Mixed Model Line An assembly process that can be used to manufacture a variety of products or product families at a given volume.

Mock Training Line An assembly line designed and constructed as a training area for new employees preparing to work in a real production environment. New employees build real products following all the rules, procedures, and protocol of a real assembly process.

No-Added Work Work performed, within a process, that does not add any inherent value to the product. Nonvalue-added work is usually wasted effort on the part of people and processes. It costs the company money, and customers are not willing to pay for it.

Operator Placement Map A simple layout of the assembly process that shows where the production supervisor should place the operators in order to produce a certain output.

Poka-Yoke Japanese term for mistakeproofing or errorproofing. A poka-yoke device prevents incorrect parts from being assembled, or easily identifies a mistake.

Production Control Board A visual tool used on the factory floor to monitor line performance every takt. Line leads or production supervisors are required to update this board displaying why or why not units are flowing at a given rate. See *takt time*.

Pull System A manufacturing system in which goods are made when needed by a downstream process.

Push System A manufacturing system in which goods are produced and then placed in the consuming process and stored until needed.

Quality at the Source An inspection concept that places the responsibility for quality in the hands of the operators. Operators are required to perform certain incoming and outgoing checks to catch errors.

Quick Changeover A setup reduction approach to manufacturing to allow for better flow of products and material in a mixed model environment. Reduces the time, resources, and cost associated with long setup times.

Rate Card A small index card that outlines the manpower and workstation requirements for the different line rates. There is one colored-coded card for every assembly line or process.

Red Tag Event A process improvement project in which unnecessary and unused items from business or manufacturing processes are removed. Used in conducting the first "S" of a 5S campaign.

Shadow Board A visual management technique that uses an outline or image of a tool to represent where it should be stored. See *visual management.*

Single Piece Flow The movement of parts or units in a manufacturing process one piece at a time.

Standard Work An agreed-upon set of work procedures that establishes the best, safest, and most reliable methods and steps for each process and each employee. These methods are clearly defined, mathematically driven, and supported by documentation.

Standard Workbook A management tool that is used to manage and monitor the assembly process. Contains all appropriate documentation including standard work sheets, rate cards, employee cross-functional matrix, operator placement map, and kaizen event schedule.

Standard Work Sheets Workstation documents that outline the work content, work sequence, time, parts, tools, and equipment needed to design and control the assembly process.

Takt Monitor An electronic display board that provides ongoing progress of output.

Takt Time German word for rhythm. The time for a unit to move from one workstation to the next to meet the required daily output.

Tower Light Colored light system installed at the workstation to allow operators to communicate with support staff and material handlers.

Two-Bin Material System A system of presenting parts and material to a workstation allowing for reduced inventory levels, reduced shelf and floor space, and more efficient communication with material handlers. See *material handler.*

Value-Added Work Work performed during the production of a product that is considered to add value to a product and for which the customer is willing to pay.

Visual Management A system of communicating information to the production floor on overall performance; tracks various business metrics. A *production control board* is an example of visual management.

Work Content A set of tasks within a workstation or work area associated with building products under standard work guidelines. See *standard work*.

Index

M

N

O

P

Q

R

S

T

U

V

W