LEAN MANUFACTURING

TOMPKINS ASSOCIATES

Supply Chain Excellence

Worldwide Central Campus

8970 Southall Road
Raleigh, NC 27616
1-800-789-1257
(919) 876-3667
(919) 872-9666 FAX
www.tompkinsinc.com

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EXECUTIVE SUMMARY

"Lean Manufacturing" may sound like a trendy buzzword, but its concepts have been implemented globally for almost sixty years. Major U.S. companies have been teaching and implementing Lean for twenty years. What are Lean concepts and how do they work? What is the goal of Lean? What are its tools? Why are so many major companies around the world sold on Lean? Simply stated, Lean works. And with proper training any company can implement Lean successfully.

Although Lean will deliver significant results quickly, Lean is not a quick-fix program. Lean is a team-based continuous process designed for the long-term maximization of company resources. Companies expecting to use Lean for a few years and then to move on to another process or program will lose the confidence of managers, supervisors, and operators. Lean demands total commitment for the long haul. A departure from Lean after implementation is worse than not implementing Lean in the first place. After selling it to the workforce, dropping Lean would show management's lack of commitment to team-based continuous improvement. Lean is a bottom-up and top-down process, and its success depends on cooperation and commitment across all levels.

This monograph provides examples of applied Lean concepts, and describes how and why they work. Lean is not intuitive; the concepts are based in logic and fact. The best proof that Lean works is seen when participating in a Lean continuous improvement team. Lean implementation, however, is only successful at those companies that have the full support of top management. With proper understanding and application of Lean Manufacturing principles, an organization will experience greater efficiency, growth, and profit.

TABLE OF CONTENTS

1.0 INTRODUCTION

Although Lean is a current business trend, it is not new. In fact, a major Japanese automobile manufacturer developed Lean in the 1940s. It quickly spread to other companies and industries within Japan, and finally the United States and West. Now, service, sales, governments, and other non-manufacturing sectors are jumping onto the Lean bandwagon.

The "Lean Concept" refers to a collection of tools used to promote long-term profitability, growth, and "doing more with less." This seemingly impossible task is achievable. In the past, increasing production efficiency required employees to work harder or longer, and machines to run faster. These methods work temporarily, but ultimately cause great problems. Accident rates increase, unions claim labor abuse, and overtaxed equipment breaks down. So, how do you increase efficiency without working harder or longer? The simple answer is by eliminating waste.

Waste normally represents between 55 and 95% of the manufacturing process. All manufacturing processes are either value-added or non-value-added. Value-added processes mold, transform, or otherwise change raw materials into a finished product. Non-value-added activities include transporting material, conducting inspections, bar coding, and others.

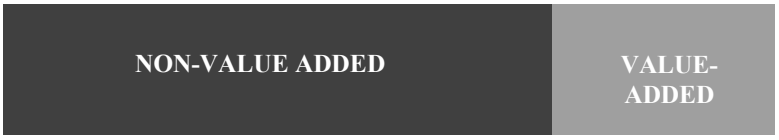

Figure 1

Implementing Lean Manufacturing involves streamlining the non-value-added processes as much as possible, because it represents as much as 75% of the total manufacturing process.

The need for Lean may be more easily understood by looking at financial models. Until thirty years ago, monopolies

existed and large companies took their existing costs, added a profit, and the result was the sales price. This formula was especially fitting for new products. When VCRs were first introduced, they cost more than $1000 per machine. The same was true of cordless telephones, personal computers, and laptops. If consumers wanted the product, they were forced to pay the company's set price. In today's market, competition is more intense and consumers are more sophisticated. They demand more products, more features, better quality, higher availability, and competitive prices. Competition is also stronger due to the multiple numbers of companies producing each product.

NEW MODEL: PROFIT = SALES PRICE - COST

Figure 2

Current cost models assume the consumer sets the sales price. Anti-trust laws have rendered most monopolies obsolete. The manufacturer or service provider now determines its profit by subtracting cost from the sales price. As a result, the only strategy for increasing profitability in today's market is to reduce product cost by eliminating waste. Under the definition of Lean, manufacturers must meet consumer demand while applying fewer resources. (Improved customer satisfaction is also a critical element of this equation.) The old cliché of "working smarter, not harder" applies now more than ever.

2.0 BASELINING AND BENCHMARKING

The first step in any improvement process is to document the company's current performance. You must know where you are now in order to determine where you are going, and how you are going to get there.

With the assistance of management and the financial group, the metrics to be tracked and measured must be established up front. Next, measurements for a minimum of twelve months should be collected in order to understand how the metrics are trending over time, and where they are when the Lean process begins. Complete buy-in is essential now before any Lean efforts begin. If buy-in is not attained from the location manager and the financial group, questions will arise later as to what savings were actually realized. Also, a clear understanding of how the savings will be calculated and valued at the end of the project must be established. Only in this way may effective measurement take place during and after each Lean project.

Implementing Lean is the easy part. Establishing a baseline and measuring financial results is not. It is, however, a critical first step in determining Lean's success. Many successful improvement efforts are never properly recognized because no verifiable starting point is established. Scrambling to find the numbers as they are needed—instead of before—decreases credibility with the location manager, corporate management, and the financial group.

It is also important to understand performance levels achieved by other departments in the same facility, other facilities in the same company, other companies in the same industry, and other industries. It is wise to know where you have been and where you are. Knowing where others have been and where others are will help the organization understand how it is doing in relative terms. This is called benchmarking.

3.0 LEAN TOOLS

Eliminating wasted time, wasted effort, wasted materials, and wasted resources may increase throughput or productivity by a minimum of 30%. Improvements of 50 to 100% are not uncommon. For example, a process that runs 20 minutes per hour, or 33% of the time on average (based on total available time), is down 40 minutes per hour, or 67% of the total available time. If, through team-based improvement efforts, the organization successfully eliminates 20 minutes of the 40 waste minutes, the result would be outstanding. The total cycle would now require 40 minutes of which 20 minutes are value-added. The value-added 20 minutes represents 20/40 or 50% value-added time.

To recap, neither speed up the process, nor require extra effort in the value-added part of the process in order to achieve improvement. Simply focus on non-value-added activities that are preventing the process from being optimized, and attack them.

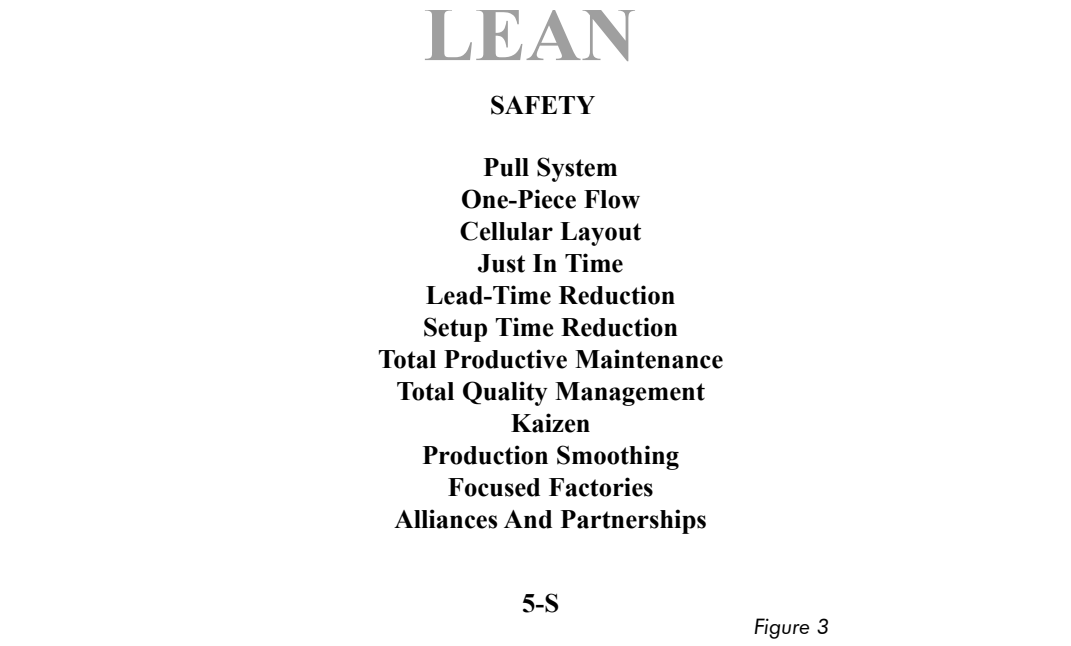

Figure 3

3.1 Setup Time Reduction

Manufacturing lead-time reduction is a primary focus in today's competitive environment. Many elements comprise manufacturing lead-time, such as material preparation, movement, and setup time. Setup time is directly related to production lot sizes. As setup times are reduced, lot sizes may also be reduced. Reducing lot sizes decreases total manufacturing lead-time geometrically, particularly when the process involves multiple operations.

The goal is not to reduce the number of setups (this will be explained later), but to reduce the required setup time that results in machine downtime for each occurrence of the setup. Simply reduce the amount of time tied to setting up the process or machine when it is not running production. This is referred to as internal setup time. Setup time that takes place when a process or machine is running is referred to as external setup time. The premise is that in many processes, the machinery is producing, not the operator. At the very least, the operator is not 100% utilized or occupied. As a result, the operator may, depending on the process and the machinery, perform some setup tasks during the time that the process or machine is running. This may not always be the case. Totally manual operations require that the operator is present at the station, or no production may take place. Typical tasks include obtaining tools, parts, and materials.

Some of the original internal tasks may actually be eliminated as in the case of multiple adjustments or “zeroing in” on a setting. Setting marks, or poka-yokes, ensure at least a starting point for settings, if not the final setting. A poka-yoke is an error-proofing device, such as the connectors used on personal computers. The poka-yoke will not allow the connection of the cable in the wrong configuration. Likewise, a poka-yoke will not allow the operator to insert the die incorrectly. Each of these

little “bites” allows us to “eat an elephant.” The “elephant” is a large block of wasted time. Most internal setup times may be reduced between 30 and 70% per discrete project, depending on the operation. The key to Setup Time Reduction projects is to revisit the setup operation periodically to audit the results from the previous project, and to reduce the setup time again and again.

For example, suppose a setup operation is observed and the following data is collected on a ten-machine department producing plastic assemblies at the rate of five units per minute or three hundred units per hour. The machines are located close to one another, but quite a distance away from where the material or dies are stored. One operator runs one machine. Each operator/machine currently produces three large equally sized lots per day. As a result, the operators perform one setup at the start of the shift and two other setups during the remainder of the shift. Each operator performs the entire setup operation by himself with no assistance from other operators or maintenance personnel.

All of the times shown in the table are initially internal to

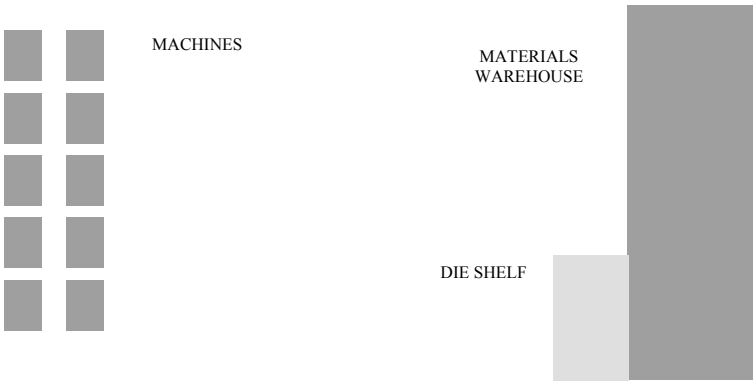

Figure 4

BEFORE SETUP TIME, REDUCTION PROJECT

OPERATION	TIME (min)
Stop Machine	*
Clean Area Around Machine	5
Fill Out Paperwork on Previous Lot	4
Return Material from Previous Lot	10
Find and Obtain Tools	3
Remove Die for Previous Lot from Machine	7
Clean Inside Die	2
Return Die / Obtain Die for Next Lot	8
Pre-Heat Die for Next Lot	22
Install Die for Next Lot into Machine	9
Make Adjustments	2
Locate and Obtain Material for Next Lot	16
Feed Material for Next Lot	3
Make Thirty Test Widgets	6
Check Dimensions on Thirty Test Widgets	3
Start Machine	*
Total External Setup Time	0
Total Internal Setup Time	100

the setup. This means that these activities are performed while the machine is not running. Specifically, the internal setup time includes all the activities that take place from the time the last part from the previous lot is produced until the time the first good piece from the next lot is produced. If any of the items were external to the setup, they would take place before or after the machine was stopped for the setup. The objective for a Setup Time Reduction project is to eliminate or reduce all internal setup activities and to minimize the external activities. The improvement team documented the project and made several observations.

- Some activities such as “Remove Die” cannot possibly be performed while the machine is running. Other activities may possibly be performed while the machine is running,

but not safely. Many internal activities may be performed while the machine is running, either before or after the setup takes place.

- Depending on contamination issues, cleaning around the machine may or may not take place while the machine is running. For this example it is assumed that the "Clean Around Machine" activity, such as removing parts from the floor, may take place while the machine is running before the setup.
- Delay filling out the paperwork for the previous lot until after the machine has been restarted on the next production lot. Obviously all of the paperwork may not be filled out before the machine is stopped, because a final production count may not be taken, until then.
- Currently tools are shared among many operators and must be located. Install five tool shadow boards to be shared among the ten machines in the department. In the rare case that both operators need the same tool at the same time, they will walk to the next tool board.
- Previously, the dies were stored on a shelf in the opposite corner of the department. One trip internal to the setup returned the die from the previous lot to the shelf and obtained the die for the next lot. Relocating the shelf to a more central location to the ten machines will reduce the distance traveled. The trips to return the die from the previous lot and the trip to obtain the die for the next lot will be split up. Obtaining the die for the next production lot will be performed before the setup, and returning the die from the previous production lot will be done after production. Removing the die from the previous lot, cleaning inside the machine, and installing the new die must take place internal to the setup. The machine will obviously not run correctly during these three activities, but their associated times may be reduced.

- During die removal and installation, a collar is rotated seven times in order to secure the die to the machine. Change the threading to allow for only one turn and the time for removing and installing the dies will be reduced.
- Obtaining the die for the next lot and preheating it, may certainly be performed while the machine is running before the setup, so these two activities will be moved external to the setup, and the machine will not be stopped while they take place.
- Adjustments still must be made internal to the setup, but this time will be reduced dramatically with setup marks and documented settings by product.
- Feeding the material must take place internal to the setup, but locating and obtaining it may be performed before the setup begins.
- Returning the material from the previous production lot will now be performed after the setup is complete.
- After interviewing the inventory control material handler and his supervisor, it was determined that the material handler could stage the material close to the machine. The handler was happy to do this because he said the operators always move the materials to the wrong locations when attempting to locate the correct materials for the next lot. The material handler also said that the operators frequently return partially consumed material containers to the wrong location. This activity would actually save the material handler time over the course of the day, as he would now not be required to go behind the operators and relocate the materials to their proper locations. The material handler is provided with a schedule at the beginning of each shift in order that he may know what materials would need staging.

- Feeding the material into the machine could neither be moved external to the setup nor could the time be reduced. After a discussion with the quality control manager, the thirty pieces produced and tested during the setup may be reduced to ten. Statistically, only ten pieces were required before startup per the control plan. The operators had always produced and tested thirty test pieces as the production supervisors had asked them to many years ago when a major customer was issuing complaints.

Some questions were asked during the training meeting and not all of the operators were ready for a change, but the team asked them to try the new procedure for one week at which time another training meeting would be held. One week later, most of the operators preferred the new procedure to the old one. Some of the operators still resisted the changes, but they agreed to continue with the new procedure. These operators did suggest two changes to the new procedure that were adopted. They also finally accepted the continuous improvement process, even if it was in a small way.

It is important to remember how important "selling the job" is to the success of a project. Simply "knowing" the numbers are correct and that the new procedure is "do-able" is not always enough.

After the Setup Time Reduction Project, the times were as follows:

The internal setup time was reduced from 100 minutes to 23 minutes per occurrence. As the setup takes place three times per machine per shift, the total daily savings in machine run time was: 77 minutes per machine setup multiplied by 3 setups per shift multiplied by 10 machines per shift multiplied by 3 shifts per day = 6,930 minutes per day or 115.5 machine hours per day. As the production rate averages five units per minute or three hundred units per hour, the department may now run

AFTER SETUP TIME REDUCTION PROJECT

OPERATION	TIME (min)
Clean Area Around Machine	5
Find and Obtain Tools	1
Obtain Die for Next Lot from Shelf	2
Pre-Heat Die for Next Lot	22
Obtain Material for Next Lot from Staging	3
Stop Machine	*
Remove Die from Machine for Previous Lot	6
Clean Inside Die	2
Install Die into Machine for Next Lot	8
Make Adjustments	1
Feed Material for Next Lot	3
Make Ten Test Widgets	2
Check Dimensions on Ten Test Widgets	1
Start Machine	*
Stage Unused Material from Previous Lot	3
Return Die from Previous Lot to Shelf	2
Fill Out Paperwork for Previous Lot	4
Total External Setup Time	42
Total Internal Setup Time	23

34,650 additional units per production day, which allows all of the operators to take every Saturday off. This is the approximate amount of production that was required to be produced every Saturday. The company saved the overtime associated with the operators, the supervisor, and the support departments. The company also was able to ship the last orders of the week at Friday midnight instead of Monday morning, as the shipper will not pick up on Saturday. Average inventories were reduced and customers were more satisfied with earlier shipments.

The four-week goal was to run twelve smaller lots on each machine per shift, but the idea had to be sold to the supervisors and operators first. Implementation without communication and buy-in would result in failure. There existed no reason to risk a backlash of disgruntled employees in order to implement the

changes quickly. These changes will result in millions of dollars in savings for the company each year. In addition, the training, cooperation, and good will earned in four weeks will pay off significantly in the long run.

Why would anyone want to promote the idea of additional setups in an operation? By reducing the time per setup, the number of setups may be increased in order to promote a more flexible schedule that incorporates shorter product runs. A "make to order" scenario would be ideal, both for the company and the customer, but depends on setup times and production rates. The concept of running smaller batches helps to avoid stockouts on smaller volume products. Another benefit is that as the operators perform more setups, they fear them less and become more proficient at performing them.

Safety, chemical reactivity, Good Manufacturing Practices (GMPs), product segregation, product contamination, space limitations, and other constraints may impose constraints on the new sequence of a setup process. For instance the material for the previous lot may not be allowed to be placed in proximity to the material for the next lot due to flammability, reaction, or to prevent accidentally re-feeding the material from the previous lot. Also, many FDA and GMP regulations require that the work area must be completely unstocked and thoroughly cleaned before the new materials and/or dies may be transported to the work area. Product quality is an extremely sensitive area. In our example, Quality Control approved the reduction in lot sample test pieces during the setup from 30 to 10 pieces. A conservative attitude toward process changes should benefit the project team. A quality issue or customer complaint will easily be blamed on a new procedure, no matter how minor the actual changes. At least initially, it may prove wise not to change any major process or testing procedure as a part of the setup time reduction project. This will disprove any accusations that the

new setup procedure caused the quality issue or the customer complaint. Normally setup time reduction projects actually improve product quality slightly, due to improved, and better-documented procedures, as well as improved Operator training. This is normally an intangible benefit, and cannot be credited as a direct result of the project.

Another option in this example could be to have multiple operators tackle the setups and/or to use maintenance or other personnel to assist with the setups. These options would be dependent upon how automated the machines are and how available maintenance or other personnel would be to assist with the setup. Ideally, machines that incorporate automation would detect the first defective part produced and would stop themselves, thus not requiring the operator to be present at the machine continuously for fear of producing hundreds of defective parts. The team concept has proven to work quite well in many setup situations.

Kitting is another setup reduction approach that is commonly used. It is most effective when the setup requires multiple internal activities that must be performed independently by more than one person. Otherwise the benefits are marginal. However, safety issues, space limitations, and confusion may result from multiple persons attempting to perform activities in sequence.

3.2 Pull System

A Pull System is a Lean tool focused on the reduction of work-in-process inventory (WIP). The concept was originally borrowed from American grocery stores where empty spaces on product shelves signaled the clerk to restock.

In a traditional batch system, each batch process in the operation “pushes” as much product as possible to the next batch process as they are measured primarily on output. In a

pull system, succeeding batch operations, where they still exist, call to the previous operation for more WIP inventory. Only a predetermined amount of WIP inventory may exist between operations. Once this amount is reached, it may be necessary to stop the preceding operation, unless it is a bottleneck operation. Even so, the procedure may still dictate that it be stopped. A visual signal or kanban is a tool used to promote a pull system. The kanban may be a card, an empty bin, a lamp, or a flag. The kanban signals the preceding process that more WIP inventory must be delivered to the succeeding process. Production rates determine what time constraints exist with respect to replenishment cycles. In some cases the kanban may be a red line on the wall, that when exposed, indicates the need for replenishment. The work-in-process inventory has not yet been totally depleted, but the need for additional stock has been signaled. Coordination of material handling is critical to the effective operation of a kanban.

Formulas for the calculation of optimal kanban quantities exist, but in practice these quantities are commonly established by consensus, rather than empirically. Many Lean practitioners mistakenly use the terms pull system and kanban interchangeably. The kanban is the mechanism that allows the pull system to operate smoothly. A multicolored andon light system is an example of a kanban for materials, the supervisor, a mechanic, or a helper. The andon light system may not necessarily be used with a pull system.

3.3 One-Piece Flow

Another Lean focus is the implementation of One-Piece Flow. The basic theory underlying one-piece flow is that there is no need to build inventory between processes, with one exception. A bottleneck operation should always have more than one unit in front of it to ensure that it never stops due to a lack

of material to process. Otherwise, it is not logical to have multiple units queued in front of an operation, unless it processes multiple units simultaneously. One-piece flow is essentially an inventory reduction effort with other benefits, such as in the areas of quality and space reduction. Errors are also reduced simply due to the reduced amount of WIP material in the area. One-piece flow is most applicable in an environment where material movement is automated. Excessive manual motions may be required to support one-piece flow in a totally manual operation, especially if the distances between stations are excessive.

One-Piece Flow is not an absolute. In many situations one-piece flow becomes one-unit flow. As an example, let's consider a medical testing device packaging line. Four devices with sequential control numbers must be placed in a carton. No skipping of control numbers is allowed. In a situation such as this, it would make more sense to group the four individual testing devices as one "unit." In this manner, the grouping facilitates keeping the four specific devices segmented from others. One-piece flow would not necessarily deliver this same segmentation. One-piece flow is a concept that is flexible enough to meet the needs of the specific application.

3.4 Cellular Layout

In order to reduce the distance between stations, the concept of cellular layout is applied. Typically product is batched at successive operations until the finished product emerges. This method developed from the notion of grouping similar operations to achieve high efficiencies of scale. (This works not only in manufacturing, but also in non-manufacturing sectors such as insurance, banking, and sales.) Each process or department in the operation has a highly specialized task.

Let's consider a typical example. Production scheduling is

responsible for scheduling the order. Purchasing is responsible for buying the raw materials for the order. Receiving is responsible for receiving and verifying the ordered materials. Quality is responsible for certifying the ordered materials. Inventory Control is responsible for stocking the materials and tracking their location. The product travels en mass from batch process to batch process until "manufacturing" takes place

Cellular operations promote the establishment of turnkey "cells" that process the order or product completely from start to finish. Limitations may exist, but the concept works just the same. The cell components are located physically close enough to each other to enhance one-piece flow, communications, quality, and multifunctionality. One-piece flow is promoted through the close arrangement of the succeeding operations, thus eliminating excessive material handling between them.

Communications are enhanced because of the proximity of the operators to one another within the cell. The lack of separation, departmental boundaries, or walls boosts communication and cooperation between operators.

Quality is enhanced through improved communications within the cell and through one-piece flow. If process ABC is producing defective parts and only one is being produced before moving to process DEF within the cell, a maximum of two defective parts will be produced before being discovered. In a typical manufacturing setting, this number could be in the thousands before the defect is discovered, if it is discovered at all.

Automation, another Lean tool, also aids in this detection. The premise of automation is that the components of the line will automatically detect defective parts at or before each new process. For example, a part from operation ABC will not physically fit in the cavity for operation DEF if the tolerances are not within spec. The line would either stop at this point, or the

part would be moved aside into a special bin. If the line did not stop, process control specifications would monitor, record, and call attention to the defect. After a specified number of continuing defects, the line would then be stopped.

A cellular layout promotes multifunctional operators. Rather than performing one continuous task hour after hour, operators are required to perform a variety of tasks and operations. Each operator now makes decisions, within specified guidelines, and discusses issues with the other operators in the cell. They function more as a team than do individuals in a batch department performing the same task.

Supervisors will appreciate happy operators who perform better and are absent less often. Employing multifunctional operators reduces the issues involved with many different job classes and wage rates; wages tend to be higher on average because operators possess more skills.

Changing from a traditional batch operation to a cellular layout is challenging for the most adaptable operator, but in the end most prefer it because it's more interesting. Operators are not being asked to work harder, but to take ownership of what they are producing. Limitations, such as the environmental or safety issues one might see in a spray paint operation, may exist in the creation of a cellular layout. Other limitations include "monuments" which are large machines not easily moved. Monuments should be eliminated as much as possible to promote flexibility and to reduce capital costs.

Perhaps most importantly, operators feel less like machines and more like thinking human beings when they practice Lean.

TRADITIONAL BATCH PROCESS LAYOUT

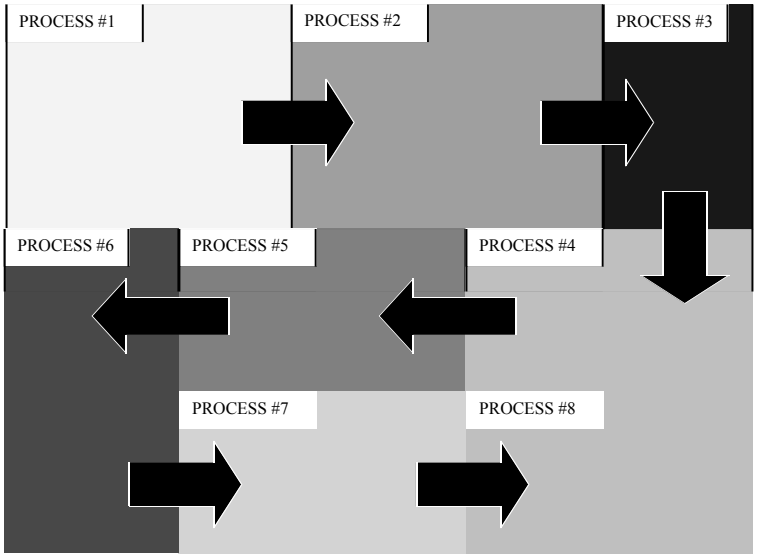

Figure 5

CELLULAR LAYOUT

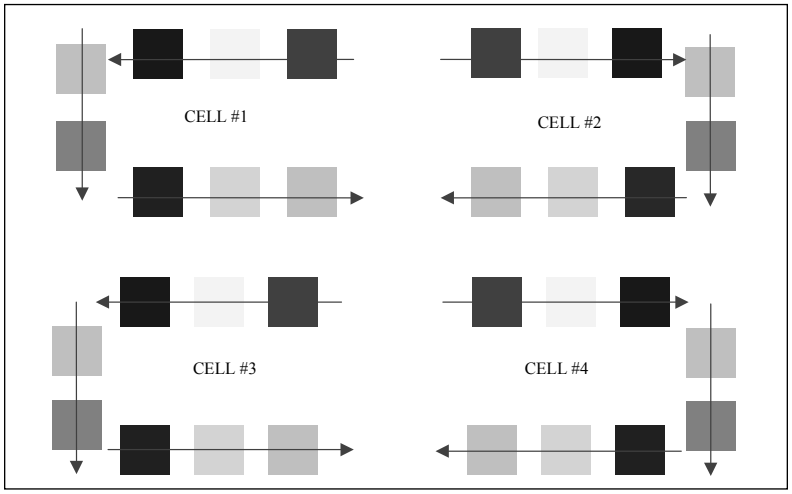

Figure 6

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3.5 Lead-Time Reduction

Lead-Time Reduction is applicable on the factory floor and in non-manufacturing arenas. One of the most common applications of lead-time reduction is new product development. Companies that minimize the time required to take a product from concept to production gain strategic advantages over the competition. Two issues reinforce this concept. First, the sooner a company moves an idea to market, the sooner higher market shares, higher profits, and lower development costs will be realized. Second, bringing an eighteen-month-old idea to market is preferable to a sixty-month-old idea. Before 1990, a sixty-month development lead-time was not uncommon for most automobile companies. Lean companies with shorter lead times could bring a concept to the hands of the consumer while the competition was still developing it, even if the sixty-month company had established the concept initially. Now, partnerships, concurrent engineering, and Leaning out the new product development process have allowed most automobile companies to shorten their lead times to eighteen months or less.

3.6 Total Productive Maintenance

Total Productive Maintenance (TPM) is a Lean concept based on three simple ideas. The first is that preventive maintenance schedules must be developed and adhere to. This simple idea is routinely ignored and abused by the best of organizations. Establishing a preventive maintenance schedule and placing it in a book is the easy part. It's much more difficult to manage a system to ensure that the tasks are being performed in the timeframe dictated by the schedule. Even when it is impossible to meet a preventive maintenance deadline, contingency plans and drop-dead dates should keep the system running smoothly.

The second idea is that extensive maintenance history exists in a database, and equipment failures may be predicted within reasonable timeframes. The database may be a manual maintenance logbook or a sophisticated software system. Either one will work, although the newer systems make the tasks much simpler. Predictive maintenance will allow the company to pinpoint failure intervals and required maintenance timeframes. Waiting to replace a light bulb when it fails is acceptable; waiting to maintain, repair, or replace a critical element of an operation is another issue. This is especially relevant if the repair or replacement could have been easily scheduled when the equipment was not running, such as a weekend or night shift. Procrastination and cost avoidance are commonly the culprits. Cost avoidance in this situation is a very shortsighted approach when thousands or even millions of dollars may easily be lost in a matter of minutes of downtime caused by a critical failure.

Last and most importantly, simpler maintenance tasks may be delegated to those who know the equipment the best. The normal temperature, sound, vibration, smell, feel, and look of a machine are clearly known by its operators. In turn, when the machine is not operating normally, the operators easily detect it. Rather than leaving a machine to beg for assistance, the operators may lubricate equipment and perform other basic or routine maintenance functions, either on schedule, or when vibrations, excessive temperatures, or other anomalies are observed. Granted not all maintenance functions should be assigned to the operators, but in some environments the operators are responsible and have ownership for all maintenance of the equipment they operate. This creates a stronger bond between the operator and his equipment, and eliminates much of the finger pointing and misdiagnoses that normally occur when dedicated personnel perform all the maintenance.

This concept also adds to the multifunctionality of the operator. Commonly both the operator and the "maintenance shop" share the responsibilities.

3.7 Total Quality Management

As a Lean tool, Total Quality Management ensures that the customer will never see a defective product or service. To accomplish this, automated and human controls must be installed that do not allow a defective unit to be processed through an operation after the one in which the defect was generated.

Quality must be managed both by operators (using Statistical Process Control, histograms, etc.) and a dedicated quality department that trains, manages, and audits the process. Specific procedures should dictate who performs each quality function and how often; otherwise chaos and a lack of stability will result.

Ultimately, however, effective Total Quality Management focuses on the needs of the customer, rather than internal requirements and agendas. The quality of the finished product still remains a function of the quality and variability of the incoming materials. Partnering and/or teaming with suppliers and vendors is critical to Total Quality Management. Managers and engineers typically focus on the process, leaving the specification, selection, procurement, and purchase of materials completely to support personnel. In many cases, these support personnel are not aware of the material quality requirements, and may simply select the least expensive option, fulfilling their own management goals and objectives. Additionally, some purchasing decisions are made based on relationships and other factors.

Total Quality Management also includes the Corrective Action System (which will be discussed in another section), the

five whys, and stop-the-line authority.

The five whys make up the Root Cause Analysis portion of the Corrective Action System (CAS). As an example, suppose your car stopped running. 1. Why did it stop running? It stopped running because the oil leaked out. 2. Why did the oil leak out? The oil leaked out because the drain plug was not tight. 3. Why was the drain plug not tight? The drain plug was not tight because it was cross-threaded. 4. Why was the drain plug cross-threaded? The drain plug was cross-threaded because the mechanic did not hand-tighten it before using the power driver. 5. Why did the mechanic not hand-tighten the drain plug before using the power driver? The mechanic was never trained to hand-tighten the drain plug before using the power driver. The process continues until the root cause of the original problem is discovered.

Simply stated, "stop-the-line authority" assures any employee that he or she may stop an entire assembly line, if necessary, to halt the production of defects. Most management teams are afraid to empower and trust factory workers to this degree. They assume that employees may want to stop the assembly line unnecessarily, or won't care about producing defects.

Total Quality Management does not require certification by an outside organization. This process has been proven to work quite well in establishing the foundation for a strong Quality Management System. It is acknowledged that some companies with unacceptable quality levels and dissatisfied customers are certified. More companies in this situation are not certified. It does not mean that the Quality Management System is flawed. It simply means that the system may suffer from poor implementation and execution.

A number of companies become certified for the wrong reasons. The two most common are to satisfy corporate directives, and as a marketing tool. Implementing a Quality Management System and becoming certified should be done only to improve customer satisfaction and loyalty. It should be noted that loyalty is very thin in today's competitive environment.

3.8 Kaizen

In order to be successful, change must take place rapidly. Unnecessary time will allow dissent to stop change in its tracks. Change is often rejected in the short-term. Kaizen is the process of implementing Lean tools in a very focused effort and a short amount of time—typically one to five days. Creating a cellular layout by relocating large machines may be performed very quickly in a team-based environment. In a traditional environment, this would not happen due to the planning and decision-making that usually must take place first.

The success of Kaizen has been well proven and documented many times around the globe. Kaizen activities have a very powerful and positive effect on team members. Due to the reduced amount of time allowed to complete the project, the team members must bond quickly to one another and organize their efforts. As the ideal teams consist of approximately four operators, a supervisor, a manager, and two support personnel, this bonding takes place over traditional lines of authority. Typically an operator may emerge as the leader of the team, although the plant manager may also be on the team. As the operators know the process better than anyone in the room, the balance of power is shifted. Operators become the experts and direct the efforts of the supervisors, managers, and engineers. Team dynamics are quite interesting at times. The higher-level people on the team must be open to this type of power shift.

Otherwise, the managers and engineers will attempt to exercise their influence upon the team, and the operators will stop participating. The team will break down and revert to the "employer/employee" scenario. A prerequisite to forming the team is to state some rules or guidelines for the operation and for the behavior of the team.

3.9 5-S

Housekeeping is a vital element of Lean. 5-S is a concept developed in Japan, but it has universal application.5-S is more a way of thinking than an actual tool. The actions relating to the organization and housekeeping of the work area are Separate, Sanitize, Segregate, Standardize, and Sustain. (Safety is always included as a sixth S.)

Let's consider a mechanic's toolbox and perform 5-S on it. Step one is to remove everything from the toolbox and only return those items that are needed. The candy, pictures, trash, and other unnecessary items are not replaced. Also, screws, nuts, bolts and similar items are not returned because they are available in the storeroom. The remaining items are steam cleaned and hand dried removing grease, dirt, and other dried material from them. The next step is to place the screwdrivers together in one section, the wrenches together in one section, the ratchet sockets in one section, and so forth. Next, label the space for each item in the toolbox and add a laminated list of items stored in the toolbox. In this manner, if any tools are missing, the mechanic will realize it immediately. Finally, a procedure for storing, using, and cleaning the tools is established, documented, stored in the toolbox, and audited weekly by the head master mechanic. The tools should now remain clean and in their proper place all of the time. This procedure also controls what will not be placed in the toolbox. It ensures that the toolbox is safe by specifying how such items

as razor blades, scissors, and punches are stored and handled. The newly organized and cleaned toolbox should not be a hazard to the mechanic.

3.10 Production Smoothing

Production Smoothing is the process of balancing variable demand over multiple time periods. Product seasonality, end-of-year demand, and other factors may cause finished goods demand to vary significantly. In order to balance resources and capacity, it becomes necessary to "smooth" out this demand over time in order to establish predictability and add order to the process. Some argue that production smoothing is "anti-Lean" because the factory floor is not producing to order. Lean advocates that the organization respond quickly to actual demand, produce it quickly, and ship it to the customer. Production smoothing is a necessary evil. As demand patterns swing wildly throughout the month or year, resources such as labor, materials, and machine capacity may not be ramped up and down without major difficulty. As a result, there exists a need to balance these resources. By balancing this demand, flexibility to respond to rush orders and the like is built into the system. If the organization were producing at full capacity with all available resources, this ability to respond would not exist. At the very least, flexibility would be constrained.

3.11 Focused Factories

The concept of focused factories takes the cellular concept to a higher level. Grouping processes by customer or product family promotes focus, thus the name. As different customers have different requirements for testing, shipping, and invoicing, it makes sense to segregate the processes, people, and other resources. It is easy to make mistakes in this regard if products for all customers took the same path through the process.

"Focused Factories" is a form of poka-yoke or error proofing.

As an example, let's assume that our company has three major customers for our finished products and each product is different. Customer A is a supplier of medical products, Customer B is a supplier of auto accessories, and Customer C is a supplier to NASA. Although certain basic elements of manufacturing processes and support functions would exist among all of them, it is clear that major differences also apply. The supplier of medical products may require a "clean room" environment for the products they receive. The automobile supplier may require QS-9002 certification. The supplier to NASA may require non-porous products. All three customers may have very stringent quality requirements, but very different documentation and reporting requirements. Resources permitting, one may clearly understand why the strategy of Focused Factories would be an appropriate choice.

3.12 Alliances And Partnerships

In order to achieve complete optimization and synergy, a competitive organization will adopt the concept of Supply Chain Synthesis (SCS), the holistic, continuous improvement process that seeks to optimize the entire supply chain rather than each link through the maximization of its eight core competencies—understanding Change, Peak-to-Peak Performance, Customer Satisfaction, Total Operations, Manufacturing Synthesis, Distribution Synthesis, SCS Partnerships, and SCS Communication.

SCS recognizes that an organization may no longer operate in a vacuum if it desires to take full advantage of resources and opportunities outside the organization. The logical key resources are the suppliers and customers of the organization. Alliances and partnerships represent a strategy that Lean corporations have strongly promoted and relied on for many years.

The concept is simple. A company wants to maintain strong relationships not only with its customers, but also with its suppliers. “Garbage in, garbage out” is an old cliché that still applies. Companies must have a stable and predictable flow of raw materials in terms of quantity, timing, quality, and price. Surprises are not desirable, and the strategy to avoid them promotes a strong communicative, working relationship with suppliers. A key point to be made here is that the relationship must be able to endure harsh issues if and when they arise. A recent example comes to mind where a major automobile manufacturer and a major tire supplier that were partnered came to blows when tire recalls rocked the automotive industry. During congressional hearings, the CEOs of the two companies strongly pointed fingers at each other. It was a very public display of a partnership gone bad.

Alliances and partnerships must have a goal to avoid issues as these, but they must also have a plan to deal with them when they do occur. Each must desire to achieve maximum benefit for all parties in the long-term.

3.13 Just In Time

The notion of pushing materials in large quantities no longer makes sense. Both the financial cost and the required resources of doing otherwise are not smart. Just In Time simply promotes the concept, both internally and externally, that it is wise to deliver materials only just before they are needed and only in the quantity required.

In the past, suppliers would strive to ship as much product to the customer as possible in order to maximize sales and profits. This was a shortsighted strategy because customers’ needs were disregarded. If a supplier pushed extra product to them at the end of the month or year, less would be required for the next period. This resulted in a slump as well as a continua-

tion of the cycle. Many companies still either do not understand this concept or do not want to change.

Short-term goals and strategies still prevail in our business environment. Lean corporations strive to maximize long-term profitability and growth, often ignoring short-term wins.

3.14 Safety And Environment

Safety is an issue that must always be considered in all operations. Lean concepts strive to provide the safest available work environment for employees, management, and the community at large. Lean also supports maintaining an environmentally sound and friendly workplace.

Consider Lean concepts 5-S and Just in Time. Maintaining an orderly workplace and a minimum amount of inventory naturally enhances employee safety and environmental awareness.

4.0 PERFORMANCE TRACKING AND CONTROL

A Lean Performance Tracking and Control System (LPTCS) should be implemented to track all of the previously agreed upon metrics on a daily, weekly, and monthly basis. Lean performance management meetings should be held at the same intervals in order to review the metrics for these periods. The meetings should be focused on the Visual Management System, which is an element of the Lean Performance Tracking and Control System. The Visual Management System tracks all established metrics on a shift, daily, weekly, and monthly basis, and is not necessarily tied to specific Kaizens or other continuous improvement projects. The Lean Performance Tracking and Control System is the top-down driver of the location continuous improvement efforts. Management should have a scheduled

daily tickler, (i.e., the daily LPTCS meeting), where the location manager will be expecting daily and weekly improvement reports. This improvement comes in the form of Kaizens and the Corrective Action System (CAS).

The CAS identifies an issue and its impact. The item is assigned to one or more managers or engineers in order to determine a root cause, a recommended solution, and a target date for improvement. The CAS is a critical element of the Lean Performance Tracking and Control System. When improvement does not take place daily, weekly, and monthly, or when the metrics actually swing in the wrong direction, the CAS should kick in with a long-term solution. The solution should address the current short-term issue, and any larger or underlying related long-term issues. If the corrective action was implemented adequately, the issue should never reoccur. The solution may involve a Kaizen, or forming a Corrective Action Team. For maximum benefit, the location manager should drive the Corrective Action System. Not only should he drive it, he should take a strong, visual, verbal, and active role in the process. Many Lean Performance Tracking and Control Systems, and Corrective Action Systems fail in the long-term due to the lack of energy and participation of this central person. Other priorities quickly develop and the process slowly erodes and eventually stops.

5.0 CONCLUSION

In the spirit of continuous improvement, projects such as these should be revisited on a regular schedule for two primary reasons. The first ensures that the changes remain in place. Without adequate controls and management, a tendency exists to revert to the old (comfortable) procedures. Periodic analyses reinforce to operators and supervisors that this was not a one-

time project, but rather a continuous process that will be revisited again and again. The second reason is to take a fresh look at the process or operation, and to find and implement more improvement opportunities. Continuous improvement is a culture, a frame of mind, and a way of business—not simply another company program. If this culture does in fact take hold within the organization, it will eventually expand beyond the factory floor. Normally, only a small percentage of the workforce will immediately embrace Lean concepts. Slowly, others can be brought on board by participating with teams or by reinforcement from other supporters. Those that totally embrace the concept of continuous improvement will apply it in their personal lives as well. It should be everyone's goal to improve in some small way each and every day.

APPENDIX
Background Information

TOMPKINS ASSOCIATES: Supply Chain Excellence

Tompkins Associates is the global leader in Total Supply Chain Solutions for operations consulting, technology implementation, and integration. For nearly three decades, Tompkins has provided expertise in warehousing, logistics, procurement, inventory, manufacturing, organizational excellence, quality, and maintenance.

Tompkins Associates is headquartered in Raleigh, N.C., and has offices throughout the United States and in the UK, continental Europe, Mexico, and Australia. Worldwide, Tompkins helps clients succeed through a combination of focused knowledge of best practices and tailored solutions. Tompkins prepares businesses to harness the energy of continuous change to achieve Supply Chain Excellence.

Tompkins Associates understands your unique needs. Tompkins' supply chain expertise helps clients work seamlessly with their supply chain partners to provide the service they need to satisfy their customers. No other firm has the capability to melt the links in your supply chain-taking you from business as usual to collaboration to velocity.

Tompkins provides solutions that are faster than fast.

Our publishing arm, Tompkins Press, delivers the knowledge today's business leaders need. Tompkins consultants have written more than 500 industry articles and given more than 3,000 presentations worldwide. As a result, Tompkins Press has the inside track on the supply chain issues facing businesses today as well as the issues they'll deal with tomorrow. We're an aggressive publisher of leading edge, pro-technical, user-friendly books and audio products.

Tompkins focuses on delivering results–integration of your supply chain, a more profitable costs-to-revenue ratio, enhanced customer satisfaction, greater operations reliability, and the release of trapped capital. Our results speak for themselves, with over 70 percent of our business coming from past clients.

Begin your journey to Supply Chain Excellence. Tompkins Associates will make it all happen.

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