Lean Six Sigma Quality Transformational Toolkit (LSSQTT)*
LSSQTT Tool #21 Courseware Content
“Total Productive Maintenance, First Line Management For Improvement”

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First Line Management, Improvement, Doing TPM

If you can’t figure out what’s wrong or how to do something, analyze it at the lowest level. This may be one of the most profound statements about management ever to be stated. This is likely relevant with regard to equipment used in production with workers on the front line—the point being that improvements may happen first and in the most meaningful ways at the lowest level—the front line of production. Perhaps most important, we must get out in production, manage at the point of production where value must be added first and foremost. Slippage at the point of production can only be compounded as you move downstream in production.

First line of management as related to equipment in production has much to do with total productive maintenance (TPM). TPM, historically, was based around the concepts of preventative maintenance. Several stages were evolved through including breakdown or remedial maintenance; predictive maintenance, preventative maintenance and then ultimately productive maintenance. While there are clear relationships to American preventative and predictive maintenance methods, productive maintenance originated in Japan after world war II. The word total in TPM brings to bear several relevant foundations inherent in TPM. Some of the key foundations of TPM include:

○ Pursuit of economic efficiency and profitability.
○ Value adding activities to maximize machine efficiency.
○ Establishes thorough maintenance systems as standards.
○ Ongoing maintenance by workers at point of production.
○ Total participation of every worker.

TPM takes a more comprehensive look at the overall production environment to account for virtually all issues and circumstances which are prevalent, and therefore which have a bearing on quality of product as well as work life. TPM includes routine analysis and inspection of all equipment and facilities to assure safe and productive work can be done.

As part of standard work procedures at work area level workers routinely check points needing periodically measured, recorded and charted. An example could be oil sampling where all oil reservoirs are sampled and tested on timed intervals, documented routinely. Oil samples from critical equipment gearboxes could be sent periodically to labs for analysis for wear, contaminants, etc. Predictive methods could be tracked by dollar amounts saved and over time the whole program could be analyzed as a value adding, cost saving element of TPM. Maintenance work orders are tracking and filed.

TPM uses simple, straightforward, checklists for operators to maintain their own equipment on timed intervals. TPM moves many predictive work and maintenance functions, based on historical data and documented SOP’s, away from specialists and to the workers themselves. The data and documentation, trended out over time, is used to create predictive maintenance which has monthly, weekly, quarterly, semi, and annual functions. Checklists are kept at operation for auditing to determine efficiency and for tracking work done to maintain tools, facilities and equipment. Routinely completed cleaning, lubricating, inspecting, and audits (periodic inspections) are “health check-ups” to prevent diseases and increase life span, as well as to keep equipment out of the hospital for major surgery and “rebuilds”.

○ Small group, team-based activities
TPM features clean facilities, well kept and orderly, created based on 5 S’s principles, and worker direct involvement at the point of production. If equipment and facility are in poor working order, barely able to function, we cannot expect satisfactory performance, let alone automation—automating what have been primarily poorly performing manual/mechanical areas of work, and speed up defective production process. Automating dull, repetitive, strenuous jobs, frees the worker’s mind to figure out how to eliminate waste and ultimately their job. As the job is eliminated, they shift to higher level work at a higher intelligence, lifetime employment ongoing and always changing position. It is critical, through TPM, that we provide quality built in through the process based on good, simple, high functioning equipment. Less downtime leads to better overall efficiencies and longer equipment life cycles. As part of TPM, most people are focused on keeping all areas clean and tidy, as part of daily routine.

**Fundamental maintenance relationships, foundations.** Maintenance, safety, quality and human factors all important service functions, merge in a rather non-obtrusive manner since they are very much concerned with quality and productivity enhancements in a “front line” point of contact management manner. Various functions and their roles will be explored relative to maintenance, all aimed at better understanding basic requirements of attitude, commitment and knowledge; and, analysis, diagnosis and troubleshooting. Each will be presented and addressed, all for the overall purpose of embracing broader maintenance relationships as prime lean areas for industrial and technological organizations and systems.

We know technology must be maintained and that it must function in a safe manner. It also seems obvious that all persons in an organization must consider one another as customers to be serviced. To the extent that technology is properly maintained, it will be safe and therefore, presumably, more productive. The extent to which we consider all others, and all functions, to require our efficient and top quality services, will directly relate to how productive our total industrial and technological organization can be, and how lean we are. However, the extent to which we also have equipment ready to perform in top notch ways when called upon to service others will be key to our ability to service others.

Mechanical equipment, production tools, transportation systems, physical facilities, and all other aspects of the technological organization require proper maintenance and service functions. Perhaps nowhere besides maintenance and safety functions are contingencies for others more noticeable. If maintenance or service functions are not properly performed in a disciplined manner, no matter what other products may or may not be produced, the organization will not function. This can also, obviously, become a safety issue since without properly maintained equipment it increases the likelihood for mechanical failure, and possible lost time accidents. All functions are contingent upon maintenance, safety and other services being performed properly for lean environments.

**Basic requirements.** Several basic requirements must be met if maintenance and safety functions are to properly serve the technological organization. The first relates to attitude, commitment and knowledge. The second is analysis and troubleshooting. Like many facets of the technological organization, only a few short years ago little commitment was required for maintenance and/or safety, and virtually any service function. As competition increased and the marketplace expanded, so has the need to properly maintain equipment in a safe and productive manner, and provide other services in a top quality, timely manner. Lean technological organizations which wish to remain competitive must have productive equipment and other systems connected with proper maintenance, safety and other service programs.

The attitude is one of understanding that without properly functioning equipment, and other internal and external services, we simply can not add value and provide useful outputs. All in the technological organization must have the attitude which commits to maintain their environment in ways all are proud of, including housekeeping, cleanliness, tidiness and safety. This, like others in the competitive organization, can not be taken for granted. All persons, at all levels and in all functions, must have this attitude and commitment. But attitude and commitment will only fall short if not accompanied with proper training and education. New systems and equipment will not be successfully learned by "fiddling around" on the job. Skills required to set up and operate, let alone properly maintain, new computerized numerically controlled, robotics, or any other high technology devices, will be far more advanced than ever before.

We cannot simply use the least desirable persons in maintenance and many other service functions. For safety reasons, and others, these functions require skills and knowledge at least
equivalent to, if not greater than most other technological functions. Perhaps more skill and knowledge is required since these persons must often deal with more types of systems, and of a greater diversity. The complexity of maintenance, safety and service functions requires that some of the sharpest individuals be involved. This continues to be an expanding area since new technological systems are requiring increasing numbers of individuals to maintain and service these systems. Moreover, the need for managers and supervisors of their own work areas, fully empowered and using the tools required to make data and documentation based decisions, is key. Persons able to do this in the future will increasingly be among the brightest and quickest in the organization.

**Analysis, diagnosis and troubleshooting.**

Talents required in maintenance, safety and service functions are not of the "rum-dum" variety. The new types of skills and talents are related to analysis, diagnosis and troubleshooting. Broad and firm grounding in electromechanical, transportation, production processing, among others are required to be successful in these fields today. Being able to grasp relationships which are often not readily apparent, but rather generally ambiguous and certainly not always right out of the textbook, are pivotal in maintenance, safety and service functions. The analytical and diagnostic brain for these functions must be able to go beyond typical rudimentary memory work and other perfunctory levels of functioning, being comfortable with novel technological circumstances for troubleshooting and other creative type activities.

**Doing TPM.**

TPM is introduced in full cooperation with the maintenance department. Maintenance schedules are produced as part of the introduction of TPM. Schedules are based on various factors including standards and regulations as well as manufacturers’ recommendations and maintenance worker experience. Production workers are involved, trained in various maintenance areas with full involvement of maintenance department. Maintenance schedules are placed close to equipment, used as SOP, and all maintenance is documented. Breakdown analysis and findings from earlier breakdown patterns are used to optimize and plan TPM systems. Bottleneck equipment are identified and supplied with spare parts as may be needed, again based on historical data and experience in work area.

TPM is introduced in incremental stages. Excellent IT system and communication support is needed (establishing, planning and executing maintenance schedules; plant availability data, breakdown frequencies and so based on data mining of historical information). The installation of “improvement teams” (comprising production leaders and production /maintenance workers) has proven to be helpful. Existing maintenance and planning groups should provide first-line support on technical issues, helping to grow TPM systems. One of the key areas will be suggestions/ideas from production workers, generally proven to be extremely important to the TPM process.

TPM promotes greater worker involvement in determining and facilitating facilities availability and minimizing unscheduled down time. Capability of production and facility to comply with quality and work flow standards can be greatly increased at the point of production. Reducing maintenance costs is a given, in part based on relationships to designing and rethinking the work process. TPM significantly improves the cleanliness and safety of equipment and of the workplace, through better use of existing employee skills. Possibilities include planning maintenance times and preparing tools and spare parts. Much of this is scheduled and managed using electronic communications to measure and display progress, results around basic areas as scope of cleaning, lubrication, mechanical and electrical work. Try out measures and standards at the work area level--setting priorities and establishing maintenance cycles.

TPM oriented Kaizen continuous improvement workshops (KCIW) can help us identify and work on maintenance related improvements. Part of KCIW’s may to identify and focus on 5S’s; dust and dirt as potential causes of friction/heat and wasted energy; development of preventive maintenance (PM’s) for each piece of equipment, perhaps correlated with lockout/tagout systems; document downtime event review where over 5 minutes downtime was observed, and so on. The KCIW can explore these type issues in fairly structured ways to determine what went wrong and why it happened? How could this be prevented in the future and who would do any necessary preventative work? Do we need spare parts, special tools and equipment close at hand or built into the system?

The 5 W’s in action can be tied to TPM as part of KCIW’s for preventative maintenance. This can be a useful way to identify improved equipment designs to help alleviate or avoid equipment failures. Preventative and productive maintenance focuses on three categories of losses; reducing downtime/equipment failure; speed losses and quality defectives.

TPM relates to the learning organization in that a common goal is to have more people understand more of the production system. People
as thinkers, need data and documentation, and inherently want to do problem solving and improvement, training, teams, and so on. TPM ties in since simplification of equipment and related production systems can be a great aid in reduction of waste and variation. Worker experience adds depth and breadth to solutions and improvements brought to the table.

Maintenance processes pivotal to the ongoing changing technological culture include preventive, predictive, remedial, plant engineering, and computerized functions. Although each is important to the competitiveness of an organization, preventive maintenance is the basic goal of good technological management. But, if too much emphasis is placed on prevention, this too can be quite costly, perhaps outweighing the cost of remedial maintenance. Preventive is that maintenance which prevents downtime due to repairs, while predictive attempts to schedule the point of breakdown due to reliability and service life of equipment. Remedial occurs after the breakdown, and is to be avoided. Plant engineering is renovation and physical plant functions, and all are generally computerized. All of these provide substantial technical underpinning, critical for servicing one another within the technological organization. These are changing, shifting toward total productive maintenance.

Total productive maintenance (TPM), like total quality management (TQM), is a organization-wide effort involving all employees. TQM, of course, is aimed at quality while TPM is designed to address maintenance issues and problems. Part of the question that many ask when confronted with maintenance issues and concerns is who would do all of the maintenance tasks that need to be done. TPM helps provide the answer: all are involved. Traditionally most maintenance functions were the responsibility of the maintenance department. As with much else in production, however, responsibilities are shifting away from autonomous specialized groups. Issues such as maintenance and quality are becoming the responsibility of workers at the point of production, or teams of persons from various specialized groups.

Reducing Deterioration. Deterioration over time is part of what detracts from maximum performance in technology, further pointing to the need for TPM. When surfaces become pitted, gears develop too much back lash, pumps have insufficient pressure, performance slumps and possibilities multiply for defects in product and breakdowns, all increasing the likelihood of decreased profitability and competitiveness. The goal is detection and correction of deteriorating circumstances.

Operators must perform daily maintenance and work area inspections, and maintenance personnel must perform periodic (monthly, quarterly, etc.) tests and inspections to determine if problems, either visible or hidden, may exist. During inspections performed by both operators and maintenance personnel, it is critical that such seemingly mundane items as loose bolts, dust and grime, leaking fluidics components, and so on be detected and corrected. These may be symptomatic of other, perhaps bigger, maintenance issues. Noises and conditions, once detected, form the basis for a TPM local team problem solving focus to attempt to determine cause and effect or corrective action. It is particularly important that operators be carefully 'tuned in' to changes in behavior of their machinery. Chatter, moaning, clicking, whistling, abrasive sounds, and other uncharacteristic noises above and beyond the normal operating behaviors would likely constitute sufficient concern for investigation. This further underscores the important role that the line operator, and teams, play in the overall production scenario.

Doing the 5 S's. Part of this also relates to maintenance in the context of the 5 S’s. The 5 S’s are sort, stabilize, shine, standardize and sustain, all heavily oriented to total productive maintenance, or TPM. Each of the 5 S words will be briefly introduced and discussed in the current section. Overall they have to do with workplace organization, heavily oriented to standard procedures. The Japanese counterpart word is listed along side each 5 S word, and a brief explanation:

- Sort or Seiri, clearing up;
- Stabilize or Seiton, organize;
- Shine or Seiso, keep it clean;
- Standardize or Seiketsu, use SOP's; and,
- Sustain or Shitsoka, train in discipline.

Sort or Seiri, clearing up. The sort function distinguishes between what is needed and not needed, and determines how to clear it up. Seiri says have only that in the workplace which is required for the job, eliminating what is not needed. Alternative storage must be secured for that which is used only intermittently. Sorting also requires determination and implementation of measures to prevent accumulation of that which is unnecessary. Seiri requires regular evaluation of SOP's and work
place layouts to determine wasteful practices and methods.

**Stabilize or Seiton, organize.** The stabilize function says there is a place for everything and everything is in its place. Seiton requires us to get organized and stay organized, placing all needed items in a proper location after each use. Stabilizing includes determining ahead of time how much of each item is needed, where it is to be placed, heights and other size limits and so on. Seiton says we should make it easy for anyone to find, monitor and use the organized items required for our work.

**Shine or Seiso, keep it clean.** Shine is a direct relationship to TPM in that we are looking for ways to keep our areas clean. Seiso focuses on the elimination of dirt, dust, scrap and other foreign matter. Part of the required tools and methods in the work area will be those elements required to keep it clean, all written into the SOP. Seiso must become a part of the routine, a method of inspection at the workplace by the operator and teams. The underlying concept behind Seiso, in addition to orderliness and good housekeeping, is that potential opportunities for improvement as problems may be identified and "nipped in the bud". Prevention of failures and breakdowns is also of obvious interest.

**Standardize or Seiketsu, use SOP's.** This relates to the inclusion of five S words into this tool and section. Seiketsu raises the question "how do we assure that the first three S's are implemented and applied?" The answer lies in SOP's, standard procedures for all to use, in written form. Seiketsu also relates directly to the final S word, sustain.

**Sustain or Shitsoka, train in discipline.** Sustain requires that correct procedures have become habit in the workplace. Shitsoka is proper training of all workers through team based daily functions. Paradigms have been shifted, buy in by all workers has occurred, and a change in habits has taken place. Sustained change is noted through visible cleanliness and orderliness, and in a change of attitude by all workers, one of welcoming a proper organized and managed work area. Shitsoka says that all persons, from top management down on, are interested in maintaining the five S words, and in finding ways to improve their use and application.

It should be clear that the 5 S's, pivotal SOP documentation components, are essential to positive change. The other key reason for their inclusion is that these steps and procedures are frequently at the heart of the ongoing improvement process. For example, if we do not include this type information periodically in the SOP, will it get done in the proper manner, driven by the operator rather than through the quality department?

**Capacity and maintenance relationships.**
Capacity determination is a method of reducing production time as one of the foundations of TPM. The production system can only produce so many units in a given quantity of time, assuming other fixed resources. However, if equipment failures and uptime are improved the system will generally be increasingly productive since more capacity is available to produce. Thus, the TPM goal is heavily oriented toward increasing capacity to do productive work as part of the production system. This is achieved largely through zero breakdowns and zero defects, both being based around some pretty basic assumptions about the workplace, related to maximizing technological capacity. First, a clean, well organized, cooperative work area will be more productive than a messy and disorganized work area. The roots of this assumption lie in the evolution of TPM and its Japanese heritage.

Relying heavily on preventive maintenance principles, TPM aims to maximize equipment usage through efforts of all employees, but is organized at a local level with small group efforts drawing on expertise as needed. TPM is an organization-wide effort, supported at all levels and requiring total participation of all employees, which pursues total effectiveness for profitability through total maintenance systems. This requires that all equipment have a maintenance plan for the entire life span of the equipment. The maintenance plan includes a maintenance prevention emphasis during the design stages, even before the equipment is built (or purchased.) TPM requires maintainability improvement efforts to help prevent breakdowns and to assist in efficient maintenance during the equipment's useful life. A final TPM feature is autonomous on-going, day-to-day, functions by operators in production as part of their duties.

TPM is an equipment intensive maintenance effort. This is not to say that people are less important in TPM than in some other maintenance approach. But, as production becomes increasingly technologically based, even to the point of near total automation and mechanization, the equipment is of paramount importance. TPM requires increasing numbers and types of human input via team.

Maximizing technological capacity through zero defects and minimal equipment breakdowns requires TPM systems and strategies for waste elimination and reduction. Zero defects and minimal equipment breakdowns also compliments the broad quality movement and just-in-time production methods. Maximum technological
capacity, full equipment utilization for profitability, comes with throughput times unhampered by quality rejects and nonconforming product.

From a TPM perspective, it is important to recognize that this also assumes clearly understood product specifications, with parallel equipment requirements. Equipment breakdown reduction can only be successful if the right equipment was designed and implemented for a given task in the first place. Finally, equipment changeover and setup time must be minimal if technological capacity is to be maximized. Time spent in changeover and setup, like maintenance, is generally not productive time, and thus must be minimized.

Successful equipment maximization will be based, in part, on accurate data kept over time. Accurate records should be kept on time the equipment is actually used on a dedicated production job, time spent in breakdown during a job, time spent on predictive and remedial maintenance not associated with a job, downtime for any reason not listed in another category, changeover and setup times, performance efficiency based on operating speeds, feeds and outputs, and others as appropriate.

**Safety Management, Quality Objectives**

A significant part of technology has to do with safety. This is true because people and technology in combination will eventually result in some form of safety related issues. Safety is a primary concern since it appears reasonable to assume that safe people will be productive people. People who do not feel safe in the workplace may be preoccupied with hazards such that they will be less productive. It is the interface between technology and people which is what we will call ergonomics.

Safety and quality relate in other ways as well. For example, if our overall work area is less than well kept, it simply reflects poor quality. Housekeeping not only relates to maintenance, but housekeeping relates to safety. If our work area is not in good shape in terms of clutter, tools out of place, hazards permitted rather than eliminated, and so on, we are encouraging less than safe circumstances—reflective of poor quality attitude. It is this interface between the worker and the work area which becomes the ergonomics question.

Another basic factor worth exploring, and establishing, at this point is the misconception of what is commonly called an accident. While we refer to most mishaps or physically damaging circumstances as "accidents", the fact is that very few situations which result in lost time, or people getting injured, are actually accidental. Rather, most so-called accidents are due to poor planning, neglected hazardous conditions, not following the SOP, removal of machine or equipment guards, violation of policy, and so on. But the key point is that what are generally termed accidental, could have very often been avoided. This speaks, in the traditional sense, to good design and management, more recently to ergonomics and team behaviors.

If we tie this more carefully back into the "quality attitude", we begin to recognize that discipline, as was established before in several tools, is at the root of safety—as well as quality. If we are disciplined in our work environment, and if we take the time to put proper plans and systems in place, we will likely not "create" opportunities for accidents. Persons interested in quality will increase the likelihood that they do not have safety problems—this is no accident. This speaks to the adage that we must work smarter as opposed to just harder. The ergonomics perspective as applied to safety for quality says we must think harder and collectively within the synergy of the team. The empowered individual and team must improve safety and quality at the workplace level, and the overall quality of cultural work life will improve as well.

**Safety objectives for quality.** Four major safety objectives are identified in this section as being part of what will lead to a quality work environment. While these are not necessarily always the case, they will generally hold true in technological organizations and industries. These include accident reduction, cost reductions, morale and productivity relationships, frequency and severity. Indirectly, the major objective is to build a proper safety and ergonomics program in the workplace, yet it is thought that the four points provided will reinforce the larger objective.

**Accident reduction.** This is a major objective related to safety and ergonomics since the fundamental interest is in reducing the number of lost time accidents. These accidents result in people losing time from work, or worse, those accidents which result in death or dismemberment. When equipment is down due to any reason, including a safety related issue, we are losing productive time.

**Cost reductions.** Accidents cost money and the costs are associated with replacing that which has been lost. This includes workers, products,
equipment, and so on, and assumes proper tracking systems are in place, as documentation and data, to know and understand cost issues over time.

**Morale, productivity and quality.** The third objective is related to attempting to improve intangible items such as worker morale, productivity and quality. If workers feel safe, they will likely have better morale, productivity and quality. This relates to the others in rather indirect ways, yet is tied directly to the basic assumptions about ergonomics. The way we organize and manage our day to day work place and functions, will be a major determinant in the quality of our outputted product.

**Frequency and severity.** A final major objective related to safety is to reduce both frequency and severity of accidents. While the major objective is to reduce accidents, it is also true that accidents will occur. The objective becomes to reduce frequency and severity of accidents which do occur. At a gross level, rather than an accident resulting in death, if the same accident results in a scrape or minor burn, this would be an obvious improvement. It is worth underscoring the reality that the actual overall objective is to put in place a safety and ergonomics program. This must be part of the culture, particularly from the team perspective.

Safety, like quality and productivity, is a concern of all people. This includes management and labor alike, increasingly a part of the team and cultural fabric. Safety particularly does require top management support if it is to be successful. It is only through visible (and financial) support from the top of the organization that safety programming will be taken seriously at the systemic level.

The point is that even with well designed and functioning empowered teams, strong management at various levels and ways must be there. This demonstrates part of the true leadership function of the manager in the future. Teams will not conjure up most of the systems addressed as safety and ergonomics of their own accord. Management leadership must be provided to build and maintain these systems. This must be done in a manner that takes operating dollars right off the top, similar to any overhead cost. This is part of the leadership challenge, further defined from the synchronous view, all consistent with toolkit precepts:

- An infrastructure, or culture, must be built for safety and ergonomics, for quality.
- We must balance safe and ergonomically appropriate work environment for quality with productivity, in real ways associated with getting product out the door.
- Teams must be built and maintained, to support and grow all persons for safe and proper work methods and systems.
- People at all levels must feel good about what they do as work, but they also must contribute to production and improvement collectively.

Specific safety programs must be tailored for any individual organization in concern. But there are several management issues related to safety which can be dealt with on a universal basis. These are listed below in several separate paragraphs, all consistent with the broad principles provided above.

**Clear responsibility.** All people, labor and management alike, must understand their responsibilities. Who will document hazards? Who will request repairs or upgrades? Who will report unsafe people? This is increasingly important in the WCTQ environment since broad job descriptions and cross functions must be prevalent. Yet safety must have specific types and kinds of ownership.

**Proper matchup.** Workers and jobs must be properly matched within circumstances surrounding safe working conditions in a broad sense. This is becoming increasingly important, and challenging, with the advent of numerous non-traditional workers entering the work force. Management, whether traditionally done, or in the team, has an obligation to properly match up talent with tasks.

**Absolute accountability.** Not only must people be given clear safety responsibilities relating to safety, but they must also be held accountable for their actions and those within their responsibilities. If people know they will be evaluated based on their responsibilities, being held accountable, they are increasingly likely to assist in facilitating safe working conditions. The team must hold one another accountable through evaluative measures unique to their culture, for safety. There must also be accountability built non-punitively at the broader systemic management level.

**Develop goals and objectives.** Safety goals and objectives can be requested from people. Done on a regular basis, this will help ensure safety from people since they will be “thinking safety”. This must tie back into the broader strategic plan for the organization, and certainly at the team and individual level. Much of the broader Kaizen and lean logic speaks to this both directly and indirectly.

**Safety dollars savings.** The only way to keep a safety program going traditionally is to be able to show actual cost savings due to safety
activities. Documentation should disclose the effects of training, committees, and other efforts to assist in improving safety. Some of the costs which can be discussed as safety related, to help build the case, could be training costs for replacement workers, increased worker compensation payments; costs of reduced output by returned injured workers; costs to repair damaged machinery; costs for clerical activities to complete forms; and perhaps others.

While we have always had to traditionally show a "safety profit", this may be changing in some subtle ways. It would be hoped that this is now so engrained in the fabric of the team culture that we would see the gains in ways identified above, but in subtle documented ways which are simply logged and monitored over time. As improvements are proposed and implemented we must show savings due to improved quality, safety, and certainly productivity in various ways associated with time and operating costs. This only happens if we have built safety and ergonomic programs systematically throughout the organization via teams.

Safe procedures. Safety should be built in to all procedures. Although the word safety may never be identified in the procedures, safety should be the standard working and operating procedure. No matter what the job, there are safe methods which can be used. These should be identified, documented, trained for, and accounted for. This is addressed specifically as job safety analysis (JSA) and indirectly throughout the toolkit as standard operating procedures (SOP). Again, the principles once discussed as JSA should become built into SOP's automatically over time, bringing safety and ergonomic issues home in a disciplined way.

Design/build-in safety. When the opportunity presents itself, either for original design or in a redesign, plant layouts, work areas, machinery and other technology related items should be put together with an attitude toward safety. Addressed further in the section titled controlling physical conditions, it goes without saying that management must take responsibility to make sure safe design is part of the technical support attitude.

Supervision at various levels. It must be recognized that one of the most important people in the management team, for safety, is the front line supervisor. If this person is effective, many safety problems will be eliminated or reduced. The issues and circumstances dealing directly with supervision, must be fully understood if we are to have effective supervisory leadership. This is a key change area where the proverbial rubber hits the road.

It must be remembered that this function occurs both at the front line, but importantly at all levels within the technological infrastructure. Any team leader, manager, or person in charge becomes a supervisor and change agent. This will frequently be the technologist, whether associated with quality or safety, or any other responsibility.

Be persistent. Safety is an issue which must be continually repeated. This can be accomplished through posters, newsletters, Friday-morning meetings, safety fairs, family safety outings sponsored by the company and perhaps others. The point is that safety can not be presented too much. Another important point is discipline in the systemic manner identified throughout the toolkit. Discipline is at the core of data and documentation systems.

Do it right the first time. Perhaps one of the best occasions for creating a safe working environment is when the new employee is first hired. Sometimes called "new employee indoctrination", this activity must be carefully planned, organized and executed to help ensure that proper procedures are given and followed. This is particularly true as we observe that many accidents happen during the first few days of work, by new employees. Other "new employee" concerns include:

- Where lockers, restrooms, cafeteria, showers and other facilities are located.
- Where first aid is located.
- Where exits for emergencies are located, and provisions for using a disaster plan.
- Providing information about benefits and other programs for employees (insurance, health and medical, vacation, etc.).
- Medical examinations for determining "base-line" health conditions for employees. This is particularly important to the organization since the employee may try to blame the organization for any number of medical maladies down the road.
- Transfers in the organization who should be treated as new employees. When people transfer from one job to another, internal, they may think they do not need "new employee" treatment. They should be given proper training and work procedures to help circumvent possible accusation, later, that every precaution was not provided.
- Provision to ask questions. Far too frequently people are not given time to ask questions.
People learn the proper approach early on, rather than learning the wrong behaviors. 

- Provisions for proper job placement for new employees. Points to include are:
  
  - Clear policy on selection and placement with general skills and qualities needed.
  - Determination of work requirements with emphasis on physiological and psychological needs, including job descriptions of all.
  - Methods and tools available to assist in determining the applicant's capabilities, experiences and aptitudes.
  - Determine any physical limitations which could be safety concerns on the job, including visual, hearing, nervous or emotional disorders, epilepsy, and others.
  - Methods for analyzing and matching job needs with applicant abilities.
  - Provisions for training in new positions after selection and placement.
  - Follow-up procedures to account for overall quality of selection and placement.

**Conduct inspections.** Another helpful management tool for gaining and maintaining safe technological working conditions is the routine inspection. These can be conducted in a variety of ways, but the intent remains the same. The inspection is intended to help discover safety and ergonomic issues and less than safe practices before they become problems. Also the inspection serves as a key piece of documentation to substantiate that the safety issues were identified for correcting. Due to costs and other factors, problems may not be corrected as quickly as needed. If an accident results from identified safety problems after the inspection process documented the hazard, but before corrected, it was documented, and management may not be accused of being negligent. Different inspection methods are used depending on need. For example, general and specific needs obviously exist, contingent on the nature of the technologies (i.e., nuclear versus general manufacturing). In either, a questionnaire or checklist system is usually needed, including corrective action follow through.

The person doing the inspection may be a significant issue as well, since management may have their own motivation for inspecting, related to much previously been stated. However, consistent with the movement to place responsibilities at the lowest level possible for empowerment purposes, it may also be highly advisable to engage the line workers and operators in a self audit for safety purposes, on a regular routine/systematic basis.

**Build off the job safety programs.** Concern about health and safety of employees away from the job, is termed "off the job safety". Since a significant percentage of accidents occur away from work, organizations are often concerned about non-work related issues. The investment the organization makes in people, and costs required to replace them, help us know it pays to worry about them off the job as well as on. Typical off the job concerns are:

- Alcoholism and drug rehabilitation.
- Stress management, general counseling.
- Vacation safety programs.
- General physical checkups.
- Driving safety, and perhaps others.

In all cases the entire family should be included, since many organizations are observing that the employee who's family is well cared for will likely be the more productive individual. Teams may actually drive and manage some of these type broader issues. Strong management at higher levels will be required to facilitate and maintain the infrastructural requirements.

**General Ergonomic Principles**

Several issues must be addressed within the broader ergonomics framework as related to quality. The ergonomic issues to be briefly addressed include human behavior and systemic safety issues. These all may also be contributing elements in the overall quality of work life and productivity. They may also have a direct bearing on safety at the point of activity. The whole facility should be built and planned with a single thought, simplifying the handling of material. Even a well thought out process is simple, with simplicity comes greater safety. Safety controls exploration, and anxiety free person can be more creative. Each of these will be briefly presented within the broader context of safety and quality work environment.

**Ergonomic principle 1: General human behavior, safety management issues.** Human behavior is, of course, at the crux of ergonomic and safety issues. And as the individual is comfortable and psychologically safe, they will tend to be increasingly comfortable. By contrast, if we feel unsafe, or worse yet, if we are in fact not safe, this
will take away productive opportunities. Several rather conspicuous elements may contribute to this:

- Ongoing hazard analyses, process design reviews, accident investigation and reduction systems in the workplace.
- Balancing and managing workloads to reduce stress and opportunities for overloads.
- Incorrect interpretation or estimation of any number of conditions, including temperature, speed, distance, mass of operation, and so on.
- Using a faulty product or process, particularly associated with poorly maintained equipment.
- Poor layout, housekeeping, illumination, or other workplace circumstances.
- Unwillingness to change, errors in operation, or irrationality due to emotional duress.
- Laziness or lack of being mentally alert.
- Stress due to personal issues, circumstances.
- Misuse of equipment, particularly shortcuts—not following procedure.
- Difficult to maintain equipment—leading to work done outside the system—not properly maintained and therefore unsafe.

While other human issues and general management circumstances can be identified, the above should be considered from the vantage point of potential areas for ergonomic improvement.

**Ergonomic principle 2: Systemic communication and clarity issues.** Mistakes and errors that you and your co-workers make may result from poor design of the displays and controls you use or other general communication issues. The configuration and layout of displays and controls, as well as how information is formatted on the systems, can enhance or hinder your performance:

- Communicating how to do and how not to do various tasks in proper SOP, OPCP, FMEA, 8-D and other documentation systems.
- Providing regular, timely training on how to use new systems or upgrades.
- Misread, misunderstood, or lack of information in the work instruction or SOP.
- Maintaining file paper trail on accidents, safety costs, corrective actions, and so on.
- Use adequate work space clearance for safe, productive, movement without encumbrances.
- Digital displays are best when precise info is needed.
- Provide ample light for detailed, precise work.
- Provide work platforms and “assists” which are adjustable and flexible.
- Design the work area, and tasks, around the smallest individual and work your way up with adjustments.

**Ergonomic principle 3: Accessibility and clearance.** Make the work and the workplace as accessible and clear as possible. When people must struggle to get to their work or to effectively interact with work, due to clutter or disorganization, it is bound to require additional effort and can lead to unsafe circumstances. Several considerations include:

- Use adequate work space clearance for safe, productive, movement without encumbrances.
- Eliminate barriers or small sized openings which slow or restrict the pace.
- Ensure visual access and clearance for knowing what is happening around workers.
- Provide ample light for detailed, precise work.
- Consistent locations for tools, materials and workers should be used. People will be more productive when necessary items to perform a task are located in the same place over time.
- A clean and orderly work area should be the rule rather than the exception.
- Design the work area, and tasks, around the smallest individual and work your way up with adjustments.

**Ergonomic principle 4: Easy Reach.** An easy way to make your work more user-friendly is to keep products, parts and tools that are frequently needed within easy reach. Long reaches often cause you to twist, bend, and strain which in turn makes work more difficult. Reach ties together many other elements. Several helpful hints for work area design related to “reach” for reducing fatigue could be:

- Use "lazy susan" type systems to locate and position work.
○ Use containers with "drop" or removable sides for quick and easy removal.
○ Reduce work surface dimensions to minimum.
○ Provide "cut outs" or forced locations in work areas to standardize reach functions.
○ Use chutes and hoppers to ease movement of work and pre-position reach functions.
○ Avoid reaching down into tubs and boxes.
○ Use mechanical "assists" such as drivers in hanging suspension, to minimize reach.

Based on work method principles, work areas, tasks can be analyzed for improvements, leading to cost reductions through time savings, quality enhancements, worker morale boosts and so on.

**Ergonomic principle 5: Proper height.**
A common workplace problem is a mismatch in heights between employees and the work that they are doing. This leads to poor postures and unnecessary work. Consider the following as ways to improve the work environment:

○ Design for the smallest person, and adjust upward for larger individuals.
○ Use tilting tables and adjustable work fixtures.
○ Design work to be done at elbow levels.
○ Use mechanical floor lifts whenever possible.
○ Bring work to worker level rather than keeping work in single position.
○ Heavy work should generally be lower.
○ Light, precise work should generally be higher.
○ Larger work is generally lower and smaller work is generally higher.
○ Stooping to the floor to pick up a tool isn’t productive, therefore all material should be delivered waist high.

**Ergonomic principle 6: Grasp, excessive forces.** Workers should not have to use their hands as a fixture for holding the workpiece. Standard metallic work holding fixtures should be used wherever possible as a standard method. This also relates to people not having to use excessive or direct forces in their work. Minimizing the number of motions required to do a task can reduce the wear and tear on your body. Overloading your physical and mental capabilities can contribute to injuries, accidents, poor quality, and lost productivity. Good design of your jobs can help prevent undesirable fatigue. Counter productive work elements surface due to hands and work pressures being improperly considered. Consider:

○ Use lighting to illuminate work to be grasped.
○ Heavy work should be handled mechanically.
○ Use total hand, power grip.
○ Avoid pinch grips.
○ Use tools that fit hands and the job.
○ Design work handles into packaging.
○ Grip as close to the body as possible.
○ Develop or tailor lifts, trucks, tooling and hand tools for your processes.
○ Hang continuously used tools, make them pull downs to reduce motion by worker.
○ Let tool work for you—screwdriver, lifts, trimming…
○ Design for motion efficiency and lack of repetition.
○ Use totes with good handles, strong, not likely to break under load.

Anything that you can do to minimize the exertion required to do your task will make it more user-friendly. Excessive forces load the muscles, creating a potential for fatigue and injury.

**Ergonomic principle 7: Posture.** Posture considerations are paramount in work design. Proper heights, reduced leaning and reaching, and adjustability and changes of posture are desirable. Changes in the approach, carefully studied and applied, can reduce fatigue and counter productivity. Use tools, equipment, and workstation layouts that allow you to work in the best possible posture. Good posture reduces the stress on your body and makes it easier for you to do your job. Several helpful hints could be:

○ Use elbow level for most tasks.
○ Do not cause workers to bend.
○ Height levels task to task should be consistent.
○ Maintain straight wrists.
○ Keep arms and elbows in close to body.
○ Maintain natural back curve, not bent by load.
○ Minimize the arm force needed.
○ Use mechanical assists when needed—lifts, hoists, conveyors, hand trucks for material movement.
○ Keep loads as close to the body as possible.
○ Reduce pulling and pushing forces.
○ Push rather than pull.

Adjustability makes it easier to customize your workstation to fit your needs. Thus, adjustability can help you to maintain better heights and reaches and avoid pressure points and awkward postures.

**Ergonomic principle 8: Minimize direct pressure.** Direct pressure or “contact stress” is a
common issue in many workstations, particularly where lifting and pushing is done regularly, extensively. In addition to being uncomfortable, it can inhibit nerve function and blood flow. Direct pressure commonly affects the:
- Palm of the hands, forearms, and thighs are key areas.
- Reduce pressure on legs and feet—use mats to stand on.

**Ergonomics principle 9: Materials handling.** Related to controlling physical conditions, manual lifting since a significant number of accidents and injuries in technological circumstances are related to manual lifting. Often loads are improperly lifted, too heavy, not gripped securely, or personal protection equipment (gloves or proper shoes) are not used. This can be avoided by simply inspecting the load prior to beginning the lifting process. The load should be inspected for stability, determine if any rough edges or irregularities of shape may cause injury, and to assure a place is available to put the item down once at destination. Several procedural points can be used to assist in proper lifting:
- Feet comfortably spread to assist balancing.
- Keep back straight to enable better leverage and helps minimize damage to the back.
- Keep the chin tucked under, again, to minimize backbone damage.
- Use the entire palm and fingers to help ensure a positive power grip.
- Keep the central body weight over the feet to help with balance.
- Arms should be kept close to the body to multiply their leverage.
- Bending should occur only in the knees.

Several other lifting or handling devices are identified to provide some perspective. One example could be pallet trucks. Non-powered types can run over people's feet, while the powered type can actually "get away from you" and strike people, product or equipment.

**Controlling Physical Conditions For Ergonomic Enhancement**

Physical conditions in the work environment are concerned with all aspects of people and their safety. Interest in physical conditions is in keeping the workplace safe, further defined as:
- Plant layout and general physical design.
- Machinery, general hazards, guarding.
- Electrical devices, equipment, hand tools.
- Material movement.
- Housekeeping and general maintenance.
- Fire control.
- Pollution, hygiene.

With the exception of housekeeping and general maintenance, each of the above are explored in greater detail, beginning with plant layout and general physical design. Housekeeping and general maintenance has been addressed throughout the tool.

**Plant layout and general physical design.** Several specific guiding principles can be identified in this area of concern. These are:
- Sufficient space for aisles, storage, equipment and so on, must be allowed. It may be wise to isolate or contain selected operations.
- Exits and stairs includes doors and locks which permit rapid exit, doors swinging outward and not directly onto stairs, consistent handrail design, and proper lighting with auxiliary battery powered lights.
- Floor openings and platforms should have covers and railing wherever possible. Use footguards around openings and platforms, approximately one inch angle iron (minimum) to diminish slipping out from under railings.
- Flammables should be stored and handled with care. Use approved cabinets, kept away from sources of ignition such as motors and furnaces.
- Lighting in all work areas should be approximately ten feet above workers and well distributed. For specialized operations such as a construction site, high intensity lamps may be needed to localize the situation. Not only is amount important, but also brightness, glare, intensity and uniformity of lighting method.
- Pipes are color coded for easy, safe identification. Dangerous material pipes are yellow, safe materials green, protective materials blue and costly materials purple.

**Machinery, general hazards, guarding.** Considering hazardous areas and/or environments, several options exist. Hazards can be eliminated, re-engineered, isolated, guarded and so on. Also, people can be trained and retrained, to properly interact and function in hazardous situations. But once training has occurred or other steps have been
taken, enforcement and discipline becomes paramount. This includes checklists or other operational guides (a vehicle "start up" procedure example is shown nearby). These should be useful when considering physical conditions, and from a general management perspective.

Guarding is another important physical condition. A key factor with guarding is "fail-safe", meaning when a worker goes wrong, rather than crushing or losing fingers, systems should fail-safe, without hurting the worker. Actions to be guarded are shearing, rotating, in-running nips (rollers), and smashing. Guards used to address these concerns are a) barriers to keep the worker from getting into machinery, b) interlocking which keeps the machine from functioning until various components are in proper and safe positions, and c) automatic guards which automatically assist the operator by providing a guard in various work positions, simply by not allowing the machine to function without the guard.

Further guarding information is noted in the following "guard criteria". Guards should:

- Enclose moving parts and components.
- Be sufficiently sturdy/strong to not fly apart.
- Use suitable materials which may be transparent, perforated, or expanded. Proper guard materials also must be thermally and chemically inert and electrically resistive.
- Afford maximum protection with minimum inconvenience. This means the guard should be convenient and not more of a hazard itself relative to the correction.
- Be a permanent part of the machine. If you are not careful, workers will remove the guard because it may be perceived as being a removable item.
- Have maintenance/inspection capabilities.

Reasons for guarding may appear minor until a worker does not interact properly with the machine. Benefits from guarding are: reduce injuries, fear, complaints, noise levels, and training needs, all aimed at upgrading quality and productivity.

Related to guarding, safety can be improved through the use of lockouts. Lockout simply means a machine can be totally and safely powered down to a zero energy state. Lockouts are locks which are placed on or near switches or other power control mechanisms. The lockout principle applies when cleaning or maintaining a machine. Any time workers wish to ensure the machine is truly off, this is a lockout application. Often, a lockout bar is used, providing a place for several workers and/or maintenance people from the same or different shifts to "down power" the machine and be assured that when they are adjusting or maintaining, or simply checking the machine it will not be turned on, endangering them. This is particularly important where many people are involved and controls are in a location many feet from the actual operation. A figure nearby shows an example lockout system.

Each lock separately placed, or the control of operation, must have a different combination so people can only remove their own lock, but not another individual's lock, ensuring credibility in the system. Typical lockout procedures include:

- Agreement is reached regarding units which are to be taken out of service.
- Point of operation controls are turned off, followed by main power being turned off.
- People who will be servicing the machine then place their locks on the control lever.
- A tag is placed on the lockout explaining the nature of the situation, who is involved, how long the job should take, and so on.
- Double check switch or valve prior to starting work, to assure there is no chance of someone inadvertently enabling the machine to run.
- After each worker completes their servicing, they should remove their lock, one at a time.
- The last person's lock to be removed should sign the tag indicating the job is done.
It is often important in locking out power to make certain all sources are dormant. This may include not only electrical, but pneumatic, hydraulic, flywheels, and other mechanical types.

**Materials movement.** In the case of forklifts, the OSHA requires specific annual training and other considerations for proper use. Among these are eight hours of training annually, in-plant licensing for operators, periodic maintenance checks which are generally done prior to each running, physical exam, and documentation of operator's vision, reaction time and coordination. Most organizations have a forklift safety training course offered periodically.

Conveyor hazards include making certain that all guards are properly installed and actually being used, and checking any sensors to ensure they can be triggered to shut the conveyor off when appropriate. Conveyors should have manual shut off safety switches at periodic locations to enable shutting the conveyor down if hazards arise. Lockouts should be used for servicing conveyors, and overload devices should be installed on the conveyor to indicate when the conveyor load is too heavy.

Chains, ropes and cables should have periodic inspections to determine when useful service life is finished. After pre-determined lengths of service, these devices should be phased out and replaced with new, fresh, units. Stretching, bending, twisting, corroding and cracking all diminish strength in these lifting devices.

**Electrical devices, equipment, hand tools.** Control of physical conditions in the technological environment includes concern for electrical safety:

- Tools/machines should be checked after each use, a function of the tool crib, including a tagging system for any item needing repaired.
- Metal appliances/devices should have three wire line with ground built in. If shorted it will automatically be grounded through the third wire rather than to the operator.
- All devices should be double insulated with cases/bodies made from plastic, if possible.
- Electrical inspections of equipment should include circuit and continuity tests to determine shorts or breaks in circuits.
- Ground fault interrupters can be placed into the power lines of equipment to accept shorts in circuits rather than reaching the operator.

**Fire control.** Another physical condition to be controlled is fire. Fire is defined as a rapid, self-sustaining oxidation process accompanied by evolution of heat and light of varying intensity. The six major sources of fire are identified as electrical, arson, smoking, hot surfaces, cutting and welding, and, friction. Methods to help prevent fires from occurring or from becoming a serious threat are:

- Provide appropriate fire extinguishers, maintenance and training for their use.
- Eliminate or confine hazardous processes.
- Install water sprinkling systems.
- Protect with fire doors to contain fire.
- Use spark-free motors and devices.
- Provide marshaling areas to direct people.
- Determine escape routes and practice it.
- Know how to access rescue, medical services.
- Conduct regular fire hazard inspections.

Fire occurs in four stages and is a function of heat, oxygen and fuel. The stages are identified as the incipient, smoldering, flame, and heat stages. The incipient stage is the fire in its initial stage, often with very little visible smoke. Smoldering is the second stage, with visible smoke clearly occurring. The flame stage is where ignition actually occurs, with flames clearly visible. The final stage is heat. In this stage heat, smoke, flame, and toxic gasses combine to provide the deadliest stage. The heat stage is deadliest primarily due to toxic gasses making it virtually impossible for people to breathe.

One key problem related to fire is liquids which give off vapors. Gasoline is a prime example. If not properly stored, some liquids can create an explosive fire hazard in the environment. Although specific safety and storage guidelines should be available from manufacturers of vaporous materials, some general storage/handling pointers are:

- Do not use glass storage containers. These can break, leading to fire-related problems.
- Do not store vaporous materials near motors or other potential sources of ignition.
- Be aware of "flash point" of liquid/vaporous materials. Some liquids can ignite simply by changes in ambient temperature.

**Pollution and hygiene.** Pollution and hygiene is another physical condition to be controlled in technological environments. Major concerns relate to chemical, physical, and biological. Chemical is further defined as atmospheric and includes fumes as in welding, gasses such as carbon monoxide, vapors and mists such as in plating operations, water pollution, and
dust and smoke. Physical hygiene concerns are further defined as heat, noise and radiation from a variety of sources. Biological sources are virtually any natural organism which can attack humans, including poison ivy or bee stings.

Common hygiene issues are inhalation, skin absorption, and ingestion. Inhalation relates to breathing, skin absorption via contact with undesirable substance, and ingestion contacted by drinking or swallowing. Most serious is inhalation since it may become a chronic respiratory issue.

Control of chemical hygiene comes through air or water samples tested under controlled conditions such as calorimetric tubes for air quality or chemical reactions for water contaminants. Physical hygiene related to heat is typically controlled through personal protection equipment. Noise can be controlled by using personal protection equipment (ear plugs), by isolating equipment, or in the following engineering approaches:

- Reduce driving forces or, vibrational surface.
- Reduce the response of the vibrating surface.
- Reduce the size of the responding component.
- Change the direction of the sound waves.

Biological hygiene can be controlled through proper precautions such as personal protection equipment to help individuals avoid contact with the source.

Personal protection equipment is a final area for physical conditions. This area of concern places primary responsibility for personal safety squarely on the shoulders of the worker requiring individuals to personally protect themselves. Various parts of the body require protection as follow:

- Head - hard hats, helmets, hoods, eye goggles, ear plugs, respirators, etc.
- Main torso - thermal suits, life preservers, visible vests, harnesses, life lines, straps/belts/nets, chest protectors/bullet proof vests, lead shields, etc.
- Arms/legs/feet - gloves, arm/leg rawhide covers, safety shoes, etc.

Personal protection equipment may be one of the most cost-effective investments which can be made in the technological environment.

Environmental 14000 Standard

Another recent ISO standard which is becoming increasingly important is the environmental 14000 standard. The 14000 standard is concerned with helping organizations to assess and address their environmental performance. The standard provides guidance to organizations in controlling the impact of their activities, products or services on the environment. Like all ISO standards, the 14000 standard provides a broader context, as a structure and management system, within which to assess the environmental performance. The elements for ISO 14000 are similar to other ISO standards, and there may be opportunities to overlap the management systems. Elements in ISO 14000, due to the specificity of their intent, also clearly require additional attention. The 14000 standard is applicable to any organization that wishes to:

- Implement, maintain and improve an environmental management system;
- Assure conformance to its environmental policy;
- Demonstrate such conformance to others;
- Seek certification/registration of environmental management system by external entity; and,
- Make a self-determination and self-declaration of conformance with this international standard.

Six elements cover major areas of concern in the 14000 standard, each listed and discussed briefly:

- General requirements.
- Environmental policy.
- Planning.
- Implementation and operation.
- Checking and corrective action.
- Management review.

**General requirements.** The organization shall establish and maintain an environmental management system, described in the remaining elements.

**Environmental policy.** Top management shall define the organization’s environmental policy and ensure that it addresses the nature of organizational activities, products and services. The policy must include a commitment to continuous improvement and prevention of pollution, and assure a framework for setting and reviewing appropriate objectives and targets for improvement over time. The policy must include a commitment to comply with all relevant environmental legislation and regulations. As a written statement these must be documented and communicated to employees and the public.

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1 ANSI/ISO 14001-1996, Environmental management systems—specification with guidance for use. Publication T 65, American Society For Quality, Milwaukee, WI.
Planning. The organization shall establish and maintain procedures to identify and maintain environmental aspects of its activities, products or services. The standard defines planning further as being related to those areas where it can control and influence where it can have a significant impact on the environment, and to use these impacts, once determined in setting objectives for improvement. The planning function shall also include consideration of legal aspects, legislation and regulations which may be appropriate to the organization and prevention of pollution. Environmental management shall include establishment and maintenance of programs and systems to assure designation and follow through of responsibilities, both in existing products, services and activities, and in new product developments.

Implementation and operation. The standard requires documentation to address and define roles and responsibilities which will facilitate effective environmental management. Resources shall be provided, and persons appointed, who, regardless of other responsibilities, will be accountable for implementation and operation of systems to assure satisfactory environmental conformance and performance. Documentation shall be in place to assure that training and education, competencies and experience are in place and evidenced in personnel for managing all systems, including emergency preparedness and response requirements. Systems must be in place to assure, demonstrate and document internal and external communications between all interested parties; and to assure accurate and timely review of all significant records and communications materials. Major environmental activities (real and potential) in operations must have written procedures identifying how to handle occurrences and non-conformances in critical functions, and the test and improvement in procedures must be demonstrable. All procedures must include how and what to measure as key characteristics in operation product, services or activities which can have significant impact, and how to determine conformance and non-conformance, particularly based on auditing procedures, and what constitutes appropriate corrective actions in same when needed.

Management review. Top management of the organization shall review the environmental management system at regular intervals, to be determined by them, to assure that the system is satisfactory. Appropriate information must be collected as part of the review, and results shall be documented. The management review will address possible changes in policy, objectives and other elements of the environmental management system, based on audit results, for continuous improvement.

Problem Solving Tools, Relationships

Problem solving is essentially about discipline and communications. Assuming teams and other infrastructure are in place, similar to what has been discussed, communications and discipline are among the greatest need. Most of the tools addressed, if not all, are about bringing (communicating) the right resources to bear on some issue, in creative and disciplined ways, and using the resources to make changes which have a positive impact toward solving problems. Several problem solving tools are presented and briefly discussed below.

Conduct surveys. Asking questions about problems in a written format, which provides responses viewed as partial or complete solutions to problems, may constitute a problem solving tool or perhaps strategy. For example, asking what the top three areas we need to address organizationally, to improve, and ways to do this may be one approach.

Strengths, weaknesses, opportunities, threats. SWOT is used when you wish to determine what people are thinking, similar to the survey type format. But the SWOT does not include a category for solutions, although this can be correlated with the basic approach. SWOT is particularly helpful for “flushing out” where we are currently related to an issue or circumstance, leading to other approaches and relying on other tools.

Prioritizing, delphi. Frequently, after we have flushed out some level of information about problems and how to solve them, it is important to prioritize and organize the problems, solutions and related information. This may be done in a strategic planning type mode, brainstorming, or other approaches, but in all cases it involves placing ideas on the table and assessing based on various factors and/or criteria. Use of Delphi techniques where persons are asked to generate their thoughts in isolation of others and iteratively send all collected thoughts back to participants, for ranking and modifications can also provide innovative solutions for consideration.

Walk through analysis. Depending on the nature of the circumstances and where we may be in the stages of solving a problem (or identifying, better understanding), it may be fruitful to go to the area where the problem is thought to exist and observe. Making notes, identifying possible solution scenarios, individual brainstorming and root cause analysis may be very useful, whether done in teams or independent of others, but at the site.

Review data and documentation. One key method for solving problems as well as coming to better understand along the way as we solve problems, is to gather and review data and documentation. Obviously this may take on many
forms, depending on the nature of the problem, but key would be to have quality charts and documents representing internal and external histories of what has transpired. Typically this will lead to more questions and “roots” to be pursued.

**Brainstorming.** Typically done in teams or small groups, this seemingly simple tool brings people together and focuses their energy toward some issue or circumstance which requires solution and/or improvement. Usually facilitated by someone knowledgeable, all have the opportunity to contribute their thinking and ideas, and the structure may also provide cause and effect structure and analysis, or other documentation for further pursuit.

**Five why’s.** Another seemingly simple tool which can be mistaken for too easy and therefore missed, is the 5 why approach to solving problems. Define the Problem in terms of 5 W and 1 H: Who- subject of product; What- object of product; When- time; Where- space; Why- find root cause for each of the above, all; important factors, how- methods. It is key that we continually ask the tough questions, sometimes seemingly “on edge” and politically incorrect. Asking why 5 times prevents us from ending the investigation before we reach the root cause, the fundamental goal of improvement being root cause identification and change to improve.

**Cause and effect diagram, or fish bone.** When probing the root cause, patience and tenacity are essential, and all significant factors must be taken into account. What data and documentation needs to be collected and analyzed? Can the problem be controlled, or perhaps further analyzed, by the variables associated with the cause? Can we prove that this cause actually happened, and in the way that we think was the case? Is the supporting data real and quantifiable? Always ask why five times, obtain root cause analysis.

Problem solving tools help isolate actual causes rather than symptoms of the cause. With each new branch of discovered (identified) cause, additional roots can be sought, until the actual root cause is presented. This occurs when no further sources of potential or real cause can be identified, and is commonly not readily accomplished. The main root represents what is thought to be the main driver of the problem. As additional points of view are brought to bear on the main driver, or main effect as it is sometimes called, these may become additional drivers in the discovery of the actual root cause. Important “foundational” elements involved are:

- Identification of as many causes of one part of the root main effect as possible prior to proceeding to any of these individually. Each cause should be clarified and explained to make certain that all persons understand precisely what is being addressed. This involves tapping a broad base of persons for information.
- After each sub-cause has been identified, it is important to treat each as the effect and further identify root causes, continuing the evolution of multiple branches of thought. This is part of why we use a structured, disciplined process to help pursue details about the issue under study--repeated until no additional causes or effects can be identified, getting to the root of the problem.
- Each solution should be questioned to determine applicability to the actual root cause or problem to be solved. This is the so-called “five why’s”. It is pivotal that these drivers and effects be flushed out through iterations and brainstorming. The further we go in the “why” process will impact on the overall integrity and robustness of deliverables.
- It is very important to have ground rules and leadership for your team. This is critical for purposes of bringing discipline and systematic efficiency to the process. The cause and effect process will break down into a “gripe” session if not for effective ground rules. This also requires strong leadership--critical to help keep the process on track and productive.
- Some type of weighting system may be applied to the effects to determine what knowledgeable persons perceive to be the main effects--and possibly the actual problem. Weighted values can be placed next to the causes and effects on the diagrams. This will be discussed later as a “multi-voting technique.
- It is important to gather additional data and/or information to support or refute a given cause or effect. This is a routine part of the overall process supporting or refuting, data and documentation collected for the problem solving process as well as part of our overall change culture.

Even though it may require several brainstorming sessions to flush out the important effects, let alone the actual cause of the problem, much can be learned--and solved--about a given problem, in this manner. In fact, the beauty of the tool is likely its ability to encourage free-thinking, and innovative solutions or partial solutions to emerge in a rather rational and systematic manner. But this is also a weakness, since it can be a misguided “black hole” of effort in the wrong direction. This speaks to having systematic rules for using tools in disciplined ways.

What is the “systematic and disciplined” approach to become a productive and useful output,
leading to ongoing improvements? The following steps are used in some form for problem solving:

- **Identify a leader.** As with most other team functions, someone will need to lead the process--and organize a structured approach something like follows in the subsequent steps. This person may be a team leader, a supervisor, and operator, an engineer or technician, or others. We must identify a leader to help flush out the critical details and information vital to the process.

- **Provide a problem focus.** A brief problem statement should provide group focus for the discussion--that is, someone will need to kick it in to high gear--the problem statement can help. The extent to which we take the time to try to assure that we have the correct problem focus may be critical in the overall process. Understanding a problem is 50% of the battle.

- **Identify major causes.** Major likely root causes associated with the problem must be shown as categories to be followed up on. While these will generally be unique to the team, the product, organization and so on, it is also true that the categories of man, machine, method, materials, measurement, and environment are the commonly identified areas for pursuit.

- **Brainstorm.** Systematic brainstorming sessions must be conducted to "flush out" the root causes related to each of the major causes. This is facilitated where ground rules exist, such as: each person has a turn, offer one thought at a time, do not criticize ideas, do not discuss ideas during brainstorming, build on each other's ideas, allow team members to pass, and record all ideas for subsequent discussion--the core of discipline.

- **Clarify each cause.** Based on root cause information flushed out, further diagrams may be needed to clarify each area of pursuit. This is a primary act of further definition for team members' benefit, to lead to enhanced communication among and between individuals, teams, departments and so on within the organization. Do not miscommunicate on issues up front in the process, leading to problems in the process down the road. Also, if an area of possible pursuit can be eliminated through "up front discussion" rather than sending people off to research it, or gather information, it will likely help protect the integrity of the system--we do not want to waste time if at all possible.

- **Collect data.** Gather data for optimum root cause analysis and problem solving. In the long run, if data can be gathered in a timely manner, and related to the iterative processes involved with cause and effect analysis, it will likely save time and help us all make better decisions.

- **Use multi-voting.** Structured multi-voting should be used to identify the most likely causes. It should be recognized that this is only one method for prioritizing the causes for further pursuit. But some systematic method should be developed and used by teams to help know which causes to further investigate and pursue over time--even for further cause and effect analysis. Several ground rules may be applicable. At the outset begin a listing, allowing each person to circle the items they deem important--items getting relatively high votes are still in the running. Second and subsequent votes allow the team a number of votes equal to one half of the remaining items. This should be repeated until the list consists of between three and seven items. These will be the most important priorities for team pursuit--the significant root causes.

- **Collect additional data.** Depending on the significance of the overall circumstance, and the problem being addressed, timing of the situation, among other things, it may be important to gather additional data. It is highly unlikely that this would not be done on technical situations involving our suppliers, customers and so on.

This fosters efficient total involvement of persons in the organization, particularly on the team, because it keeps all persons focused on the issue(s) at hand. It also discourages finger pointing and finding blame, since the majority of the group energy is drawn to positive and pro-active elements in the discussion rather than negative baggage of the past.

This also helps prevent problems from recurring. For example, finding the root cause in the first place will tend to help eliminate the problem altogether up front, thus reducing the likelihood that the problem will resurface. Assuming someone is assigned to follow-up on the root causes, and report back to the group at some future date, the likelihood of recurrence is reduced once again. Since we have all been involved in the broad discussion and focus group through our team effort, we have now been further educated from several cross functional perspectives. Several possible/likely causes are identified that can be resolved over time.

Simply identifying and articulating the problem is a substantial part of the actual corrective action program. Figuring out what the problem for action, may be the most important part of the problem solving process. Far too frequently groups or teams simply can not get off dead center, because
we do not actually understand what the root is. Actual plan of attack for solving a problem is formulated in the actual raw process of cause and effect. As root causes are massaged, we should begin naturally articulating this into a plan of attack, or a project plan for the team or individuals related.

We should also be able to "backward plan", using our paper trail of activity in the cause and effect process to feed into strategic planning and other important future orientations for longer term improvement. Consider the power of involving customers and suppliers in the process, bringing their ideas and "demands" into the flow of information. Cause and effect can be a key source of information for long term strategic planning and improvement, both directly in the process, and by studying and analyzing results in documented form over time for "voice of the customer and process" direction.

**Problem solving and brainstorming for improvements.** Part of the systematic method for making ongoing quality improvements is effective problem solving. While it is true that it is less effective to solve problems which enable "putting out fires" rather than affecting proper long term decision making, it is also true that technical problems must be solved on a regular basis in organizations. Eight steps can be identified for problem solving. A brief explanation of each step includes the following:

- **Identify the problem.** The theme or problem is related to objectives to be accomplished or specific problems which have arisen.
- **Set parameters.** What are the reasons why the problem was selected. What is the problem? What are the expected results? What is not the focus of the problem?
- **Analyze the problem.** This analyzes through organization of different parts of the problem and its sub components--cause and effect.
- **Preliminary ideas selection.** This identifies possible remedial actions and alternative solutions. Selection of the best plan based on various inputs and information occurs.
- **Decision identification.** Best option in action.
- **Analyze decision.** Comparison between original plan targeted results, value to the organization.
- **Prevention.** This is action to prevent recurrence, standardization of necessary steps or establishment of procedures and training.
- **Future planning.** Remaining problems and current solution analysis/impact cause reflection on next planning stages.

Brainstorming is an idea generating activity, usually conducted in groups of 3-12 people (this can vary). The basis for brainstorming is that groups typically can be more creative and productive relative to an individual based on a synergistic affect. Human imagination applied to a problem with some reflection and freewheeling assists in the success of brainstorming. It is necessary to have a group leader to help focus, and some method for documenting ideas generated, and a relatively comfortable atmosphere and agreement on the topic or problem. The problem focus provided through previous steps identified should be used wherever possible.

When the process is actually being conducted all members should be encouraged to participate, providing only one idea per turn (to help avoid anyone dominating the process). People should be sequenced regularly to help provide ideas, and no criticism should be allowed. The following "idea spurring" questions should be asked to assist in generating "free wheeling" and creative ideas:

- Can the unit be put to other uses?  Are there other uses if modified--or if not?
- Can a unit be adapted? What else is like this?
- Can we modify the unit or component? Can, or should we, change meaning, color, motion, sound, odor, taste, form, shape?
- Can we add to unit, component?  What? Where? Can frequency, strength, size be changed?
- Can we substitute? What else? Other plans?
- Can we rearrange? Other layout? Other sequence? Change place?
- Can we reverse parts, components? Opposites? Turn backwards, upside down, inside out?
- Can components or parts be combined? How about a blend, assortment?

While other questions can assist in enriching and guiding the brainstorming process, the above points should aid in moving the process forward.

If the problem is not clearly isolated and understood, we are less likely to address actual root causes. The problem may be at least half way solved when it is thoroughly identified and stated, with all details and documentation. Given clear understanding of the problem, it may require several brainstorming sessions to flush out the important effects, let alone the actual cause of the problem, much can be learned--and solved--about a given problem. This is encouraging free-thinking,
innovative solutions to emerge in a systematic manner.

**Open agenda.** One of the techniques, related to cause and effect and brainstorming methods, which should be used as teams mature, is termed the open agenda. This allows the team opportunities to address items and areas which may not otherwise come up, and do it in a fairly systematic and disciplined manner. At some point it may become the primary tool for organizing and guiding the team efforts, including follow through on activities and issues. The team or leader requests items for action which may not have originally been part of the problem focus or agenda. This allows "openings" in an otherwise structured approach, and permits persons to bring new findings forward for the group.

**More on team-based problem solving.** It may be important to use an as newly formed team, brought together for resolving an issue, as opposed to an ongoing or standing team. It is important that knowledge be inherent in the team, appointed with other concerns in mind for proper cross representation organizationally. The team should be large enough to accomplish the task but not so large that it becomes cumbersome, unmanageable. A team leader should be identified, with all persons’ function and other critical information, to assist in logistical and managerial issues. Typical questions include:

- Do all persons have a reason for participating?
- Do all team members agree with selection and participation of all other members?
- Do all members understand why they are on the team--and is this clear to all involved?
- Has time been set aside for all members to allow reasonable, responsible, participation?
- Do we have appropriate authority represented in the group to "get the job done"?
- Does participation consider areas and issues affected by team action and outcome?
- Is the customer viewpoint adequately and properly represented?
- Can communication, internally and externally, be done in a timely and appropriate manner?
- Do we have sufficient guidance to provide direction and help "keep us on task"?
- Have we been given sufficient information, or access to address and resolve necessary issues?

An immediate answer may be less important that our ability to reach out and take care of those concerns which may arise in the future. This is important when considering an increasing reliance on teams of operators and individuals who traditionally may not have the authority required for such matters. Success or failure in many circumstances will be directly related to the way we structure the team.

**Flexible Improvement In The Workplace.** A graphic nearby depicts relationships for team building, problem solving and improvement. Appreciating that the team requires data and documentation seems less difficult to understand on the surface, relative to how to conduct the broader problem solving act.

It is the synergy inherent in, built around, and between the data, documentation and leadership, all synchronized toward the collective team effort which can and must provide the technical solutions' infrastructure as well as mechanism. This only happens if proper design consideration is given to infrastructure and organizational aspects technologically and regarding human resource issues.

The overall problem solution will be a function of three fundamental phases, each wrapped within the broader context of data, documentation and synchronized leadership as depicted throughout the tool kit. The phases are assessment, analysis and action, each to be further explored and defined within the remainder of this section.

**Toolkit Relationships For Technical Team Building, Problem Solving And Improvement.**

This would seem to be at the core of the concept of ongoing improvement. The graphic nearby provides the three tiered linear relationship between
assessment, analysis and action, all related and ongoing based on feedback within the context of problem solving. While depicted as a straight line linear function, obviously the functions will not always be this discreet, straight forward and simplistic. Relationships embodied provide a useful strategy for the context of bringing forward technical solutions and improvements.

**Assessment.** During the assessment phase of problem solving, the team must document the current circumstances surrounding the problem or opportunity for improvement. This may involve demographic data such as persons and equipment involved, process flow charts of the macro process as well as the micro process. Regardless, much documentation will be involved to flush out the "who, what, where and when" type issues surrounding the way we currently do what we do. This could be a total line or production job site at the macro level and a micro work area within the broader system further analyzed. Both would likely require layouts, time and cost data, standard operating procedures, and flow charts on the current process and system.

Product design and specifications documentation would also be well advised as part of the assessment. Various tools for data analysis and documentation would begin to be formulated as a function of the nature of the product and process. It should also be clear that the data and documentation tools selected and used in the assessment phase will have a direct relationship to outcomes overall for the study in general, and subsequent phases in particular. Based on a thorough survey of all persons engaged in the work areas, it is quite likely that specific areas for improvement will be identified and explained, from a problem solving and system. This could be a total line or production job site at the macro level and a micro work area within the broader system further analyzed. Both would likely require layouts, time and cost data, standard operating procedures, and flow charts on the current process and system.

**Analysis.** While the major focus for assessment was to determine the current methods for processing product, the analysis phase builds on and around the assessment. Data and documentation begun in the assessment phase are fine tuned and multiple iterations may be required based on further analysis. Various experiments or trials may be run to determine optimum conditions or to further analyze what was flushed out from the original assessment. Pivotal in the analysis phase is the establishment of baseline data and documentation as performance baselines upon which to base measures of improvement. As baselines are established, sources of variation are determined, focused on and causes flushed out for optimization. Stabilization in process must be achieved in reasonable ways, facilitating a clearer understanding of broader relationships in production process. As this occurs, factors and levels appropriate for further study will begin to surface. But this all assumes that under control conditions can facilitate a sufficiently "noise free" circumstance for focused improvements. This analytical environment can demonstrate optimum conditions in process.

Conflicting views or information may be found in the assessment, requiring various analytic tools and/or further clarification. Tools being required at this phase may consist of basic data such as attribute and variable charts. When these tools are used in the team mode, the overall complexity of the problem solving situation has shifted. Perhaps only one or two tools will be used, rather than all at the same time. But the array of tools available for analysis should not be understated. The number of iterations with any one tool, to continue to interpret and understand the overall problem circumstance for improvement, will vary. Quality of problem solution will determine whether further iterations may occur.

**Action.** The final phase of a problem solution will be recommendations for action. Actions consist of new procedures to be followed uniformly in the process, new equipment based on conclusions that processes analyzed were not capable, or others. All of this drives establishment of new standards, training and additional studies. Assuming new equipment is needed for implementation, new studies and iterations will be required. Additional training or better gaging may be needed, or shifts from one characteristic to another identified to be studied. Costs of such actions will need to be detailed and presented with justifications for changes.

**PDSA as an improvement system.** Use of the SOP, in any of the forms presented, must be identified and explained, from a problem solving and improvement perspective. Based generally around the PDSA presented earlier in a separate tool, the SOP can be paralleled in its use. PDSA stands for plan, do, study, act. This logic system, and graphic is put in motion with the SOP as shown nearby to solve problems and improve gemba:

- **Plan.** This identifies problems for pursuit, raising and clarifying questions, addressing the five W's, and use of SOP's in gemba.
- **Do.** Pursuit of root causes based on analysis and observation, and collection of data for documentation and further study.
- **Study.** Actual Kaizen is pursued at this point, predicting and comparing documentation and data for evaluative feedback into the SOP.
- **Act.** Changes are performed in the SOP, providing improvements at gemba, reductions in muda.

Ideas
are sought to plan for the future and further Kaizen through SOP.

As applied to SOP Problem Solving.

Relationships to documentation and training, and teams and leadership, are also apparent and all must recognize the importance of the SOP as a documentation and communication device. Many persons, depending on function, may not have had a great deal of involvement in building and/or using the SOP. As teamwork and cooperation become increasingly prevalent for all persons, particularly for supervisors and operators, it is believed this device will become more useful and necessary.