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"The TOOLS of QUALITY"

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1. Objective Of Presentation :

This presentation deals with "tools of quality" as they are used for analysis and solution of Quality problems. Ability to use these "tools" is the necessary prerequisite to implementation of Quality Improvement (QI) initiatives , which must be based on facts and analysis.
Specifically, the following will be discussed :

- Foundations of Quality Improvement
  - Quality Improvement process
  - Statistical thinking
  - Variation
- Specific "tools" and their application :
  - brief description
  - area of application
  - key considerations for use

2. Introduction .

Continuous Quality Improvement (QI) requires dealing with a variety of situations which can best be approached through understanding and analysis of the many influencing factors. This analysis is facilitated by the knowledge and use of the many techniques developed for just that purpose, which are collectively called "tools of quality".

Just as production of an item or a provision of a service requires tools and skills, so in QI the "tools of quality" and the skill at using them is a pre-requisite which enables organizations to identify and correct the root causes of their difficulties. This cannot be accomplished without basic understanding of the investigative and analytical techniques .

Approximately 60 different tools have been identified, including those for statistical analysis. A selection of these tools will be discussed in this presentation, **excluding** the statistical techniques which do not lent themselves to a short presentation and have been extensively described in the literature.

Other tools, especially those dealing with QI process have not been so widely disseminated, so a brief selection of those will be discussed. This will partially address the

need for managers to understand and appreciate the scope - breadth - of the tools available and their field of application.

The tools can be broadly divided by their principal purpose, such as :

- **idea creation** - creation of new ideas or better defined and organized ideas
- **process analysis** - understanding of a work process
- **cause analysis** - discovery of a cause of a problem or situation
- **planning** - developing a plan of action
- **evaluation** - selecting the best choice or evaluating the result
- **data collection and analysis** - collecting data or analyzing data collected

When searching for the right tool , three questions must be asked :

- what do we want to do with this tool ?
- where are we in the QI process ?
- do we need to expand or to focus our thinking ?

The QI process goes through alternating periods of expanding thinking to generate many different ideas and then focusing the ideas to specific objectives, such as defining the problem or identifying the root cause.

The expanding period is creative and can generate new and innovative ideas. The focusing period is analytical and action oriented. To obtain results, at some point you have to ***stop considering options, decide what to do, and do it.***

3. Foundations of Quality improvement .

Quality improvement process.

Its self-evident that in a world where nothing is perfect, everything can be improved. The incentive for improvement depends on evaluation of costs versus benefits. As law of diminishing returns comes into force, some improvements become less attractive. Striving for perfection can be very costly.

There are three key considerations which form the basis for planning and implementation of improvement :

a) What is to be accomplished ? (statement of "mission"). The answer to this question will provide an objective for improvement efforts. It will guide efforts and keep them focused. Using appropriate data will ensure the aim is focused in the right area.

b) What changes can be made that will result in improvement? This question is answered by developing options for changes and testing one or more on a small scale to predict the effect that one or more changes would have if they were implemented. Testing might reveal unplanned side effects or lack of improvement in the targeted performance area.

c) How will a change be assessed ? (measurement). This question provides criteria for knowing whether a change actually results in improvement. If a change is made, measures of the criteria improve and the improvement is sustained, than a process improvement has occurred.

To help implement changes and develop meaningful tests, the PDSA (Plan-Do-Study-Act) cycle is used as framework for an efficient "trial and learning" methodology. Repeated use of the cycle promotes the sequential building of knowledge.

Build-up of knowledge and understanding is required in the following areas :

Appreciation of a system. The concept of a system is a useful framework in which to think about quality improvement. It is essential for answering the question - "what is to be accomplished" ? An important aspect of managing system improvements is to choose the aims of the various improvement activities so that the efforts complement each other.

Data are needed to verify the prediction that the change will be an improvement. Relevant data is useful in answering " what is to be accomplished ?" and also provides some of the background to answer to "how will a change be assessed ?"

Understanding of **variation** is important in answering "what changes can be made that will result in improvement ?" Some ideas for change based on knowledge of variation are:

- realizing that reduced variation is often a significant improvement
- realizing that absence of performance standards contributes to variation
- using control charts to prevent overacting to variation in individual data points

Developing a change. To improve a stable system, fundamental changes are needed. These changes should avoid :

- adding complexity to the process
- focusing on people rather than on the system
- adding more of the same - more money, more people, more time etc.
- introducing additional quality costs (inspection)

Testing a change is used before full scale implementation. An important practical consequence of testing is that some tests will fail and that something will be learned from these failures.

There are a number of **barriers to QI** which need to be considered and overcome. Some of these barriers are :

- bureaucracy, which is typically risk adverse, inefficient, inflexible, rule and analysis oriented and dependent on centralized decision making
- personnel regulations which are often outdated and difficult to administer
- lack of political support within the company

- management turn-over - managers may be gone or transferred before they can provide lasting support to QI efforts
- lack of resources due to lack of commitment to QI on the part of senior management
- resistance to change. To overcome resistance, changes must be well planned and communicated to employees in advance. Incentive to improve quality, productivity and customer satisfaction must be provided.

Statistical thinking and understanding of variation.

To be effective in implementing improvements, managers must understand and use basic statistical concepts - such as **variation** - and also apply **"statistical thinking"**, which is a mind set - a way of thinking, behaving, working, taking action and interacting with others.

There are three key components of statistical thinking :

- process thinking
- understanding variation
- using data to guide actions

Key aspects of **process thinking** are :

- all work is a series of interconnected processes
- majority of the problems are in the process
- focus must be on fixing problems, not blaming people

Understanding variation means accepting that :

- variation is present in everything
- existence of variation provides improvement opportunities
- improvement comes from reducing variation
- decision making process takes variation into account

Using **data to guide actions** means accepting that :

- data, interpreted in the light of subject matter knowledge should drive actions and behavior
- key measures must be identified to obtain relevant data
- trends in key measures must be displayed graphically
- using data is the key to enhancing process management and process improvement

There is **variation** in all aspects of our lives and we constantly make decisions based on our interpretation of the variation we encounter. Quality characteristics of a process or a system will vary, and that variation has two causes :

- **common causes**, which are inherently part of a process, hour after hour, day after day, and affect everyone working in the process

- **special causes** , which are not part of the process all of the time or do not affect everyone, but arise because of specific circumstances

A process that has **only common causes** affecting the outcomes is called a **stable process** or said to be in the state of statistical control. A stable process implies that the variation the outcomes is predictable within statistically established limits.

A process whose outcomes are affected by **both common and special causes** is called an **unstable process.**

As special causes are identified and removed, the process becomes stable, with several benefits arising:

- performance of the process is predictable, therefore there is a rational basis for planning of improvements
- cost and quality are predictable, although not necessarily acceptable
- productivity is at maximum, costs at minimum under the existing system
- effects of changes in the process can be measured with speed and reliability

The stability of the system does not mean that everyone is happy with the state of affairs, but only that the magnitude and frequency of variation will remain unchanged until a **fundamental change** (improvement) is made . A stable process can be improved through a fundamental change in the process that reduces or removes some of the common causes. Instituting of fundamental (significant) change is the responsibility of the management.

Tools of Quality.

One of the most important sources of information relating to a process, event or a situation are the people involved. In order to successfully determine the root cause it is essential that their opinion on the matter be obtained. They can provide the background and the flavor which cannot be obtained from paper reviews of objective information.

It's not easy to get people to open up and offer information which may sometimes reflect poorly on their judgment and performance and therefore any interviews must be structured in a non-threatening and non-punitive way.

This can be helped by adopting the following attitudes :

- the belief that all people want to perform well , within the restrictions imposed by the management system
- the recognition that, at some time, mistakes will be made by all people
- people generally feel badly when things don't go well and are willing to help to improve matters

The other very important input to decision making is information based on relevant data. The quality of data directly effects the quality of decisions made. Therefore, there is a need

for a systematic approach to data collection and analysis, that is a part of decision making process.

When planning a data collection activity, it is important to :

- identify what questions are to be answered and what decisions are to be made
- define what information is needed to answer the questions
- analyze the existing data to determine whether it can be used
- state possible consequences of using incorrect data
- determine the budget available for the data collection and analysis project

Having the background information and the relevant data, it is time to identify and analyze improvement opportunities , make decisions and take action. Analysis is carried out using some of the following - and many others available - "tools of quality".

Root cause[1] analysis.

Any problem that occurs within an organization will be the result of either one or a combination of difficulties associated with **people, documentation or equipment.** It is essential to avoid the natural inclination to look for a "quick fix" to significant problems and instead to submit problem resolution to a **disciplined analysis** which would take into account possible contributions from these three elements. Root cause analysis is any method used to identify the root cause of performance problems and adverse trends.

A variety of undesirable events and situations occur during routine operation of a system. All of these events are investigated to some extent and most are resolved through application of routine corrective action.

Management has the authority and the responsibility to determine which of the remaining problems the plant can "live with" and which must be investigated and permanently resolved. Events that require root cause analyses should be selected based on previously established criteria and taking into consideration event type and performance trends.

The following should be considered when establishing the criteria and threshold for root cause analysis

- consequence of the event in relation to plant safety, personnel safety, plant or equipment reliability
- sequence of occurrences or multiple failures during the event
- recurring operational, maintenance and human performance problems, or equipment failures
- unexpected conditions encountered during the event
- previous corrective actions taken by the organization for similar events which should have corrected the problem

[1] *root cause :* the fundamental cause that, if corrected , will prevent recurrence of similar event or adverse condition

There are many techniques that can be used to perform root cause analysis. The best technique is the one that can accurately identify the root cause of a problem and its permanent solution, and can be understood by the user. Regardless of the method used, **factual evidence must serve as the basis for any conclusions.**

The more common techniques used for root cause analysis include :

- The process diagram which establishes a chronological sequence of events leading to the problem. Once the relevant events have been identified and placed in their proper sequence, a a question can be asked - "what allowed this to happen ?".
- Barrier analysis identifies the barriers and controls which would remove or reduce hazards, enforce compliance with procedures and make targets invulnerable to hazards.
- Change analysis compares the present state of the system (the real, non-functioning situation) with the prior state of the system(when it was working properly).
- Human performance evaluation, the objective of which is to determine the causes of poor human performance

Analysis must investigate the systemic factors[2] which permitted the event to occur.
These are :
- personnel -training, communications, human factors
- procedural - quality and availability of procedures
- equipment - design, selection, maintenance, installation
- materials - specification, quality, storage, environment, identification
- environment - working conditions, access, ergonomics, hazards

Root cause analysis should be formalized and must be performed by people **experienced in the problem area being addressed and trained in the analytical techniques** used. It is important to ask searching questions of the people directly involved in the event and to consult with others who have intimate knowledge of the situation and circumstances leading to it.

Data collection and trend analysis, root cause evaluation and corrective action process are **interactive, interdependent and collectively serve as the organization's problem solving and improvement program.** Consistency amongst these elements must be maintained for long-term problem resolution.

The effectiveness of problem solving efforts can be further enhanced by personnel training in the basics of problem identification, investigation and correction. Pro-active management style and use of multi-disciplinary teams are also effective methods for addressing process problems.

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[2] *systemic factors :* the way the management organizes, plans, controls and provides for Safety and QA in the five areas listed. In other words, how easy/difficult it is to avoid mistakes

Difficulties with root cause determination are reflected by long-standing problems where corrective actions have not been effective. This is the outcome of actions that correct symptoms only, but fail to correct the root cause and so a similar problem arises in another area.

Benchmarking.

Many organizations posses incomplete information about what is the best in their field.. Consequently, innovation and improvement targets are set internally based on past performance. The result are conservative plans and activities that are inadequate compared to the rate of improvement necessary to remain successful.

Comparative benchmarking is a competitive tool that lets organizations break free of theses self-imposed limitations and reach for breakthroughs. It is a self-improvement and management process that must be continuous to be effective. It cannot be performed once and disregarded thereafter.

Benchmarking is a process of continually comparing an organization's performance on critical customer requirements against those of the "best in their class" organizations recognized for their superiority in performing certain functions.

Benchmarking benefits an organization through :

- enabling the best practices from any industry to be creatively incorporated into the processes of the benchmarked function
- breaking down ingrained reluctance of operations to change. People are more receptive to new ideas when those ideas did not necessarily originate in their own industry
- identifying a technological breakthrough which would not have been otherwise recognized and applied
- enriching contacts and interactions of personnel involved in benchmarking, thus making them more valuable to the organization.

Cost of Quality analysis.

Cost of quality means those costs incurred because of poor quality, which would not be incurred if things were done right the first time every time. In this analysis one looks for activities which incur cost of quality.

There are three types of activity which incur costs to be eliminated :

- inspection to determine whether an error or failure has occurred
- fixing or correcting errors which are identified before customer is affected
- damage control which is correcting or disposing of errors after the customer is affected. Also, handling problems which arise because the customer has been affected.

There is a fourth type of cost of quality : **prevention.** It usually is preferable, cheaper and easier to prevent problems from occurring than to try to repair them later. Quality improvement is based on preventing problems from occurring.

The cost-of-quality analysis is a way of studying the flowchart of a process to identify problems. It helps a team to look critically at individual steps of a process to find opportunities for improvement.

The analysis should be done :

- when flowcharting a process, to be sure that cost-of-quality activities are included
- after flowcharting a process , to identify problems, potential causes and areas to concentrate improvement efforts

Cause and effect diagram (fishbone diagram)

The fishbone diagram relates causes and effects. It immediately sorts ideas into useful categories.

This technique should be used when :

- broad thinking about possible causes is desired
- the team's thinking tends to stagnate and fall into ruts

Cause and effect diagram is best suited to a team working on a problem. It will focus the participants on the issue at hand and allow them to sort ideas into useful categories.The technique can be learned easily by people at all levels of the organization and applied immediately.

Following considerations should apply :

- the fishbone diagram should broaden a team's thinking. To help this to happen :
  - determine in advance the major categories of investigation, or use the generic ones
  - focus on those categories where ideas are few
- a traditional and widely used set of generic categories is: equipment, personnel, materials, methods and measurement
- the problem should be thought about broadly, including the environment, policies and external factors. All causes should be considered, not just those within the team's control span. It can be useful to understand all causes.
- someone outside the team should review the completed fishbone diagram for fresh ideas. Also, to ensure that the diagram is complete, each member of the team should review it the next day.
- broad based participation in the team should be the rule, with staff from various functions within the organization participating.

- a constructive attitude may be encouraged by stating the desired result, rather than the problem as the objective of analysis. For example "100% customer satisfaction " rather than "customers are dissatisfied".

Histograms.

A histogram is a graphic summary of variation in a set of data. The pictorial nature of a histogram enables us to see patterns which are difficult to see in a simple tale of numbers.

Histograms should be used to :

- analyze quickly whether the process can meet the customers requirements
- see whether a change has occurred from one time period to another
- determine whether the output of a process is distributed approximately normally
- to communicate the distribution quickly and easily to others

There are several common patterns of variation which are reflected in typical histogram shapes, such as :

- normal
- skewed
- double peaked
- plateau etc.

Histograms must be carefully interpreted with following considerations in mind :

- the data plotted must be representative of typical and current conditions in the process. If the data are old or uncertain (biased) it is best to gather new data to confirm and enhance conclusions
- conclusions should not be based on small sample. Any conclusions from a histogram with less than 50 observations should be questioned.
- any interpretation of a histogram shape is only a theory which must be confirmed thorough additional analysis and direct observation of the process
- if a process is stable, the histogram can predict future performance. If a process is not stable, the histogram merely summarizes past performance

Pareto chart.

Quality Improvement teams use Pareto chart extensively to focus on the important few causes of trouble. A Pareto chart is a bar graph with the length of the bars representing frequency of occurrence.

It should be used when :

- analyzing data by groups to reveal unnoticed patterns

- trying to focus on the most significant problem or cause
- communicating with others about significance of data
- relating cause and effect, by comparing a Pareto chart classified by causes with one classified by effects
- evaluating improvement, by comparing before and after data

The chart is based on the Pareto principle : **80% of the trouble comes from 20% of the causes (population).There are "vital few and trivial many".**

The best Pareto chart uses a measurement that reflects cost to the organization. Rather than measuring the number if items, it may be more useful to measure dollars, time or some other indicator of cost.

Check sheet

A check sheet is a structured, prepared form for collecting and analyzing data. It can also be used to confirm and record that steps of a process were done .

Check sheet should be used when :

- collecting data on the frequency of patterns of events, problems, defects, defect locations, causes and so on.
- collecting data from production process
- data can be observed and collected repeatedly by the same person or at the same location
- standardizing a long list of actions, such as multiple preventive maintenance checks on a piece of equipment

The following considerations apply :

- layout of a checklist is important. Checklist should be structured for easy data collection and minimizing the possibility of errors.
- illustrations may be used to make the form easier to fill in and interpret
- data collected doesn't have to be technical or complicated, but it should be simple and meaningful, particularly to the customer.
- check sheet should be kept near where the data is to be recorded