Winter 2011

Automotive

EXCELLENCE

Letter from the New ASQ Chair

Methods vs. leadership, Which Matters Most?

Ford Motor Company Host 2011 Awards Banquet at the Automotive Hall Of Fame

Quantum Quality

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2011-2012 Division Council Roster

Editor-in-Chief: Rob Langdon
Publication Committee:
Ha Dao, Jim Odom,

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Features

Upcoming Events

ASQ Automotive Symposium

April 16, 2012 - Macomb Community College, Center Campus - Metro Detroit

See the ASQ Automotive Division Website for updated information - **www.asq-auto.org**

ASQ AUTOMOTIVE DIVISION

VISION: To be the worldwide automotive industry's leader on issues related to quality
MISSION: To facilitate continuous improvement and customer satisfaction by identifying, communicating and promoting • Quality knowledge • Management's leadership role • Industry comparison • Professional development • Recognition • Opportunities to network
CUSTOMERS PRIMARY: Automotive division members • Automotive suppliers - all tiers • ASQ sections • Division sustaining members • Potential Automotive Division members
SECONDARY: Automotive original equipment manufacturers (OEMs) • Other ASQ divisions • Strategic alliances - SAE, AIAG, SME, ESD, ASI, organized labor • Community colleges/universities • ASQ headquarters/Board of Directors/Technical Council
TERTIARY: Quality award initiatives (federal/state/local) • Standard activities • Automotive dealerships • International global markets • Aftermarkets/service parts • Third party registrars • Recruiters / consultants

Letter from the Editor

Rob Langdon,
2010-2011 Publications Chair

Welcome to the Fall 2010 Edition of Automotive Excellence. I would first like to thank Terri Pratt for her effort and support in making the Publication Chair transition a smooth one, and for providing outstanding editions the past two years. This edition is the first online only publication, although a limited number of printed versions will be available at ASQ Automotive Division events and promotions. **OLD INFO**

The benefit we receive from Automotive Excellence is made possible by the contribution of ASQ members, and the sharing of information and ideas related to the quality profession. I encourage each of you reading this to consider making a contribution of your own, as I know each of you has skill sets and information of value to other ASQ Automotive members who are eager to share this knowledge.

In this edition, I had the pleasure of interviewing Dr. Jay Zhou, recipient of the Quality Professional of the Year Award. Jay reflects on the factors that have led to his recognition as a quality leader. Jayne Vize covers the highlights of the 2010 Awards Banquet.

Chris Hermenitt gives insight into working with Japanese Customers and concepts that can lead to improved relationships and business growth.

Frederick Hume and Mary Beth Soloy discuss the Steps Toward Closing the Software Gap.

I look forward to working with and hearing from you and welcome any and all submissions for Automotive Excellence. Remember, we need to hear what you have to say.
All past publications are also available at asq-auto.org. Please visit us.
Please send articles to Rob at: ralangdon58@hotmail.com.

My best wishes to everyone,

Rob Langdon
ASQ Publications Chair 2010-2011
ralangdon58@hotmail.com

Our New Website

We have completely revamped and upgraded our new website.

www.asq-auto.org

ASQ Automotive Division: Letter From The Chair

Kush Shah
Automotive Division Chair
asq.automotive@gmail.com

It is my pleasure to have assumed the Chair of the ASQ Automotive Division effective July 1, 2011. I appreciate your continued support through your membership. I would also like to thank Ha Dao, the Chair of our Division for the last two years, under whose leadership the division made great strides in increasing member value and visibility in the automotive industry globally.

It is important for all of us to build on this momentum, so I will like to share our key objectives for the 2011-2012 fiscal year, developed from the input of our members:

- **Increase Member Value** - Expanding services to our members including free webinars, a yearly symposium and Automotive Excellence magazine with increased articles on relevant topics. I am also interested in exploring other innovative ideas that can increase member value.

- **Core Tools Development** - Establishing a leading role in auto quality professionalism by developing and delivering training on PPAP, APQP, FMEA, SPC, and more.

- **Global Outreach** - Recognizing global auto industry growth; more actively developing relationships with our members in various countries with strong automotive industry experience; and exploring the organizing of appropriate events in those countries, including activities such as training and seminars.

- **U.S Outreach** - Reaching beyond the U.S. Big 3 OEMs and engaging other OEMs and Tier 1 & 2 suppliers in the ASQ Auto Division. We may invite these OEMs and suppliers to join our council.

- **Collaboration with other Professional Societies** - Engaging with other societies and organizations that play an important role in the automotive industry to draw upon their knowledge and experience. These organizations include - AIAG, CAR, SAE, SME, and others.

- **Student Outreach** - Getting the next generation engaged in ASQ Auto Division early by collaborating with universities that have strong and high quality automotive programs.

I have several requests for all of you:

- If you would like to volunteer or have any ideas for the division, please feel free to contact me:
  Kush Shah, Automotive Division Chair
  asq.automotive@gmail.com
  http://www.linkedin.com/profile/view?id=10220294&trk=tab_pro

- Visit our website at www.asq-auto.org to access valuable information including past webinars and past issues of Automotive Excellence magazine.

- Join the ASQ Auto Division Group on LinkedIn

- Check your profile on My ASQ, the members-only section of **www.asq.org**, and opt-in to receive emails from the Automotive Division with information on upcoming free webinars, seminars and upcoming events along with electronic copy of Automotive Excellence/

I look forward to serving the members and taking the ASQ Automotive Division to the next level so that we can all be proud of our contribution and accomplishments.

Sincerely,

Kush Shah
Automotive Division Chair
asq.automotive@gmail.com
http://www.linkedin.com/profile/view?id=10220294&trk=tab_pro

Methods vs. Leadership, Which Matters Most?

by Richard Shainin

Richard Shainin, Executive Vice President
Shainin LLC, Northville, MI 48168

The Question

During a recent meeting with a client's executive team, a general manager asked me which mattered most: the effectiveness of the technical methods or the strength of the leadership. My immediate response was leadership strength. I knew we were arming the problem solvers with effective tools, but we needed continued and expanded leadership support to increase the value we could deliver. Later however, as I considered the question further, it was clear that both are required and together they create the synergy that neither can achieve alone. Treating methods and leadership as independent inputs to a full factorial experiment is one way to consider the question. Methods may be effective and ineffective, and like them, leadership may be strong or weak. Let me explain a few possibilities.

Effective Methods

Effective methods solve problems reliably with speed and minimal resources. They have recognizable characteristics: convergence, revelation, confidence, finality and depth.

Convergence means investigations follow a progressive search that measures progress by how much has been eliminated rather than what's been found. Sherlock Holmes expressed it well in Sir Arthur Conan Doyle's "The Sign of the Four:" "Watson, how often have I told you? When you eliminate the impossible, whatever remains, however improbable must be the truth." Effective methods converge rapidly on the true root cause by eliminating the impossible.

Revelation refers to uncovering surprising cause-effect relationships. The true root cause for many problems is often a complete surprise; it frequently involves interactions among independent inputs. Experts are unable to imagine these relationships. They have to be discovered.

Confidence comes from a team's ability to switch the problem off and on. Problems are often intermittent as the root cause shifts from a problematic level to a safe one. When a problem disappears, teams are anxious to declare victory only to have the problem return. If the team can't turn the problem on again, they haven't found the true root cause. They may have found part of the answer, but their insights are incomplete.

Finality means the problem is solved once and for all. Once the root cause has been discovered and confirmed, sustainable corrective actions must be applied.

Depth ensures that physics of the failure mode are understood. Depth comes from a "5-why" mentality, making cause-effect linkages until the problem solver is past symptoms and to the true root cause.

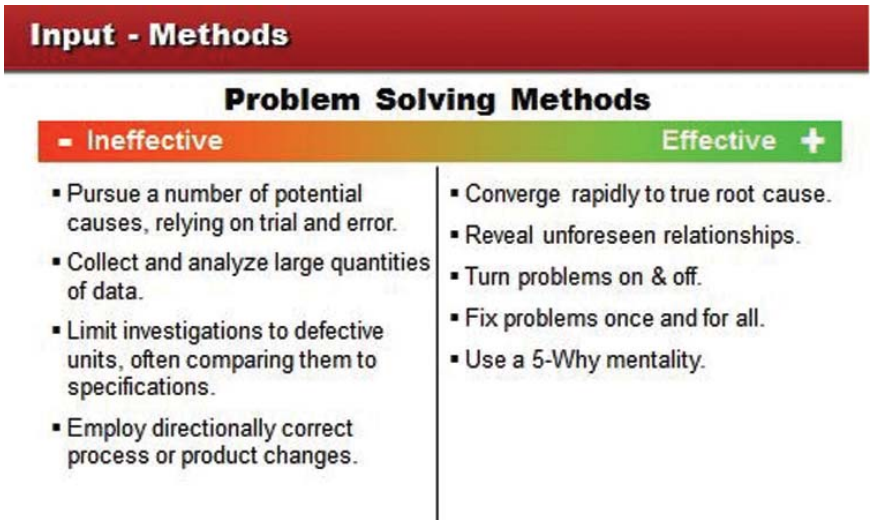
Ineffective Methods

Ineffective methods produce lots of activity but inconsistent results. Experts produce long lists of possible root causes based on their knowledge and experience. As they pursue multiple possibilities, problem-solving activities diverge.

Ineffective problem solvers often analyze large quantities of data hoping to find a pattern that leads to the root cause. Often, the data are time based. Unfortunately, many things changing with time have no relevance to the problem. Furthermore, the analyzed dataset may miss the true root cause.

Another common approach inspects defective units, comparing features to specifications. The problem solver suspects any features found out of specification. Unfortunately, close inspection will reveal a number of out-of-spec features that have nothing to do with the problem. Quite often, the true root cause lacks a specification because the relationship to the problem was never recognized.

Difficulties in finding the true root cause often lead to unproven product and process changes. For example, a cracked flange can be redesigned to be thicker. The added material provides more strength without reducing variation in strength. This may reduce the incidence of problems without eliminating the problem. It guarantees added costs and may lead to other problems.



Methods vs. Leadership, Which Matters Most? *continued*

by Richard Shainin

Strong Leadership

Strong leaders assign scarce resources to high-value projects. They provide strong sponsorship to problem-solving teams. And they leverage lessons learned to improve organizational capability. While selecting projects and leveraging lessons learned contribute to the value gained from effective problem solving, sponsorship is the key to success.

Strong sponsors understand the methods well enough to ask probing questions that support good strategy. They recognize the importance of containing the problem to protect the customer but understand that containment does not solve the problem. They often separate containment activities from problem-solving activities.

Strong sponsors remove roadblocks that keep teams from making progress. They monitor progress with frequent short reviews, rather than waiting for the teams to schedule updates.

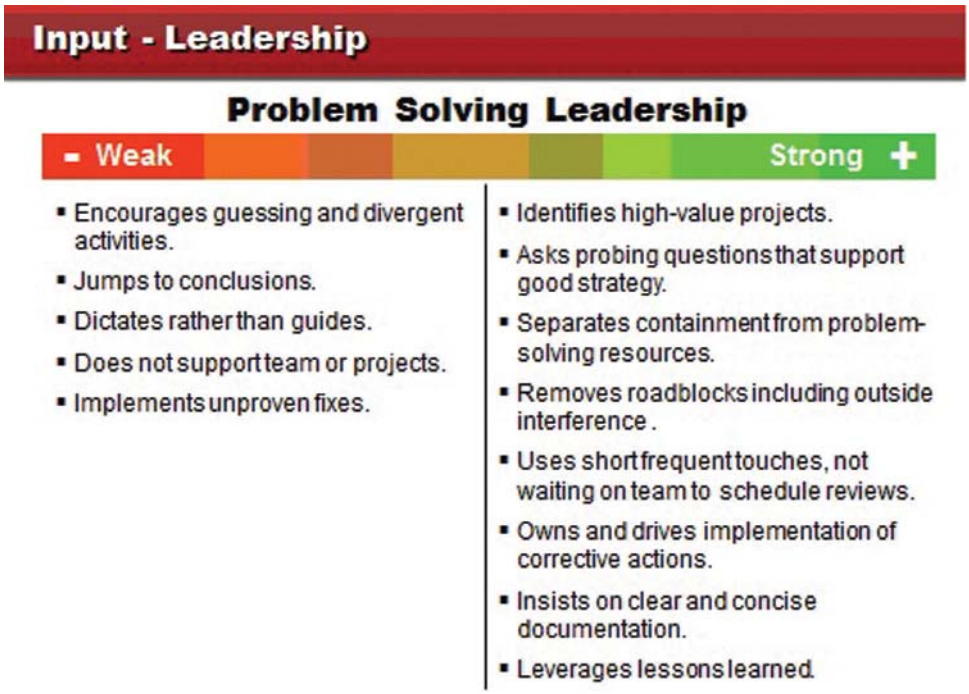
Once the team has discovered and confirmed the true root cause, strong sponsors take charge and drive the implementation of corrective actions. Finally, strong sponsors insist the teams create clear and concise documentation on strategies learned and key relationships uncovered by the investigation.

Weak Leadership

Weak leaders do not seek out problems; they seek to avoid them. They encourage guessing and divergent activities hoping that some action will solve the problem.

Weak leaders jump to conclusions and dictate actions to their teams rather than guiding them with good questions. They expect people to find time to solve problems while still handling normal day-to-day responsibilities and expect team leaders to overcome obstacles alone.

Weak leaders implement unproven fixes and have often moved on to new assignments before the futility of their efforts is revealed.



Results

With two independent inputs --methods (effective and ineffective) and leadership (strong and weak)-- there are four independent combinations and four outcomes. Three of the four outcomes produce poor to mediocre results. Only one outcome is worth pursuing.

Weak Leadership Using Ineffective Methods

When weak leaders deploy ineffective methods, the organization seldom finds the true root cause of a problem. This leads to frequent design and process changes in a futile attempt to find something that works.

Organizations with weak leaders and ineffective methods can develop a culture of excuses. They accept expert opinions that some problems are inherent in their processes and cannot be solved without new process technologies. When problems become intolerable, they create lots of activity with inconsistent results.

Customers become unhappy and learn not to count on these organizations. From a lean perspective, there is an abundance of waste in containment, in extra inventory for protection, and in extra resources spent in problem-solving activities.

Weak Leadership Using Effective Methods

When weak leaders hire or train skilled problem solvers, projects drag on because the problem solvers are not given the time or resources to uncover the answers. When the problem solver does find the true root causes, the solutions are seldom implemented.

Frustrated problem solvers seek more satisfying jobs, resulting in high turnover. Finally, customers become frustrated. They know their supplier has found the root cause but hasn't implemented sustainable corrective actions.

Once again, waste is high.

Methods vs. Leadership, Which Matters Most? *continued*

by Richard Shainin

Strong Leadership Using Ineffective Methods

Strong leaders are customer focused and understand the importance of good problem solving. Unfortunately, they may not be aware of effective methods. As a result problems are contained quickly, but few projects advance beyond the containment stage.

A plateau is quickly reached as easy problems are resolved but more difficult problems are only contained. There is a strong customer focus but uneven results as spills occur when containment fails.

Waste is still high with large containment costs and long project durations.

Strong Leadership Using Effective Methods

Arm strong leaders with effective methods and they will produce outstanding results. The combination produces synergy (the whole is greater than the sum of the parts).

Problems are solved quickly and effectively producing a low cost of quality. Each problem solved improves the organization's capabilities.

Skilled problem solvers become effective at preventing problems. Leadership can shift some of the focus upstream to new product development and achieve trouble-free product launches.

Problem solvers can also address throughput problems, increasing equipment availability and process efficiency.

Customers receive good product on time at a reasonable cost and become more loyal.

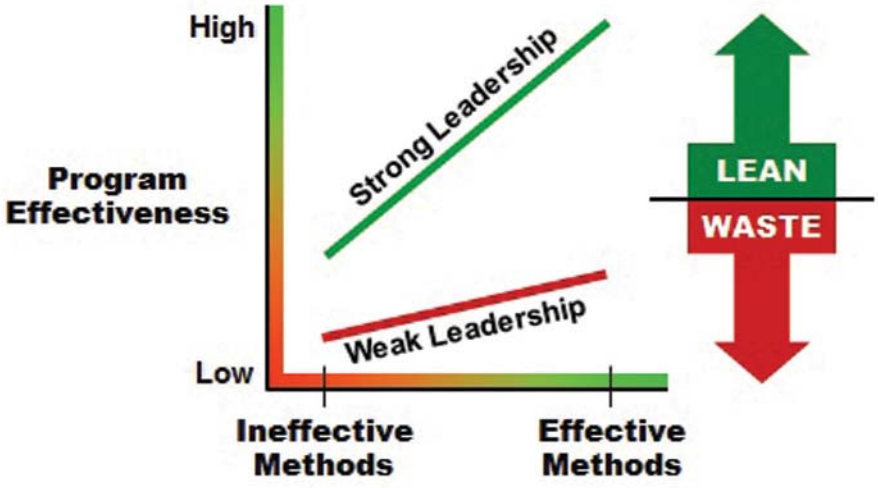
This is a lean combination.

Results

Problem Solving Methods

LEADERSHIP	Ineffective	Effective
Weak	▪ Frequent product and process changes. ▪ Culture of excuses: –Perception that defects are inherent in process. –Lots of activity, inconsistent results. ▪ Unhappy customers.	▪ Solutions are found but not implemented. ▪ Projects drag on. ▪ Personnel turnover is high. ▪ Customers are frustrated.
Strong	▪ Problems contained. ▪ Plateau reached, as low hanging fruit is picked clean. ▪ Customer focus, but uneven results.	▪ Low cost of quality. ▪ Successful product launches. ▪ High throughput. ▪ High customer loyalty.

Response



You Need Both

You need strong leaders with effective methods to create a problem-solving culture. Lean exposes waste. Lean organizations strive to uncover waste, find ways to reduce or eliminate the waste and then find more. The process is a journey, not a destination. Creating a disciplined problem-solving culture requires a similar journey, focusing on waste in the problem-solving processes.

Successful leaders learn to recognize problem-solving waste. They become sensitive to phrases like: "I think..." and "We are trying A and B and C. They understand that activity is not the same as progress to a result. And most importantly, they do not allow their teams to implement unproven fixes.

by Jaynie Vize

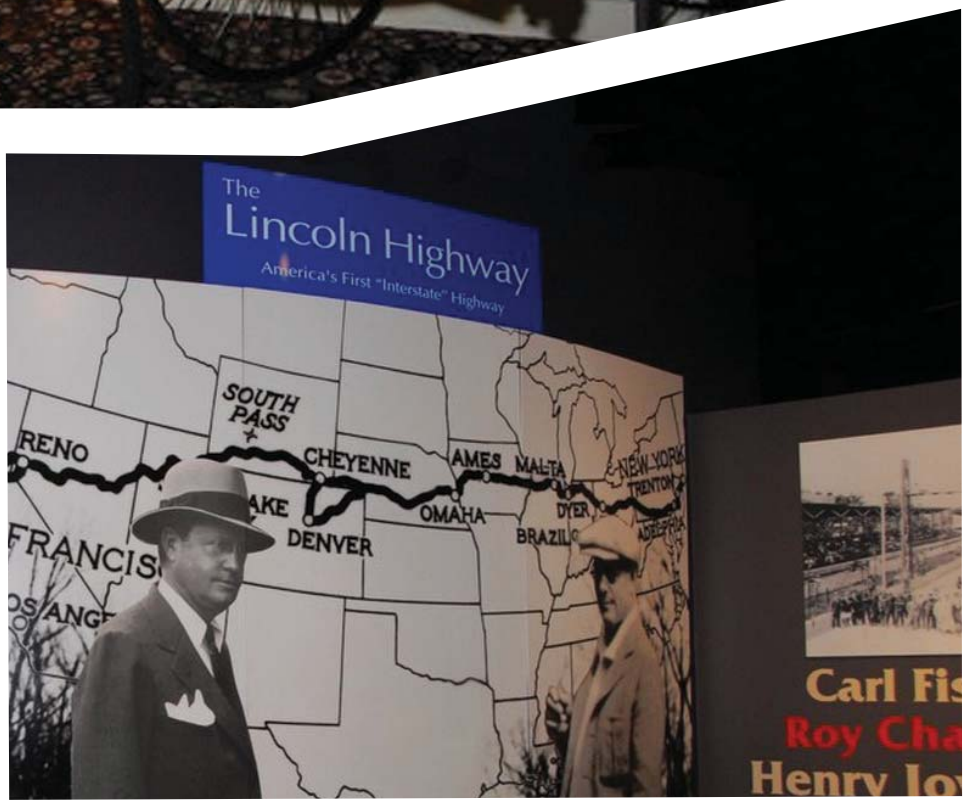
FORD MOTOR COMPANY HOST 2011 AWARDS BANQUET AT AUTOMOTIVE HALL OF FAME

Ford Motor Company was the Host Sponsor for the 2011 Awards Banquet held on June 21, 2011 at the Automotive Hall of Fame in Dearborn, Michigan.

Ninety guests were on hand to acknowledge the achievements of eleven individuals who have contributed significantly to the success of their industry, their companies and society.

Prior to the Presentation Ceremony, the Guests had an opportunity to tour the Automotive Hall of Fame Museum.

This was a fine opportunity for many to relive the "old days" and touch a bit of Automotive History and Memorabilia that isn't available elsewhere.



2011 Awards Banquet *continued*

by Jaynie Vize

The catering service provided an excellent dining experience with Hors D'oeuvres and a buffet that got everyone in the mood to heartily welcome our Keynote Speaker, Bennie Fowler, Ford Group Vice President of Global Quality and New Model Launch.

Keynote Speaker, Bennie Fowler

Specific Automotive Awards were presented by the Awards Chairpersons as follows:

Our **QUALITY PROFESSIONAL OF THE YEAR AWARD** - established to recognize individuals in the Quality field of the automotive industry who have made significant contributions in Leadership in implementing continuous improvement, services provided to the community to further the understanding of Quality systems, support and encouragement of new and innovative ideas, and high regard for team benefits - was presented by Kush Shah to Mr. Mike Rall, Corporate LSS Master Black Belt, at Cooper Tire & Rubber.

Kush Shah **Mr. Mike Rall**

Mary Beth Soloy **Bennie Fowler**

The QUALITY LEADER OF THE YEAR AWARD - established to recognize the quality leadership contributions of an outstanding automotive industry leader - was presented by Mary Beth Soloy to Bennie Fowler, Group Vice President of Global Quality and New Model Launch at Ford Motor Company.

Cheryl Denman **Ha Dao**

The WILLIAM P. KOTH AWARD - established to recognize currently active Division Members who have given outstanding personal service for the promotion of the division and the American Society for Quality - was presented by Cheryl Denman to Ha Dao, Chair of ASQ Automotive Division.

2011 Awards Banquet *continued*

by Jaynie Vize

Harold Brubaker **Walter Oldeck**

Walter Oldeck **Jennifer Schneider**

The JUDSON C. JARVIS AWARDS - established to recognize individuals who make the most significant contributions to the success of the Automotive Division Events - were presented by Harold Brubaker to Walter Oldeck, Internet & Marketing Chair for ASQ Auto from Delphi and Jennifer Schneider, Treasurer for ASQ Auto from Continental.

Larry Smith **Dr. Basem El-Haik**

The CECIL C. CRAIG AWARD - established to recognize excellence in the development of outstanding technical and managerial papers - was presented by Larry Smith to Dr. Basem El-Haik, for his book "Software Design for Six Sigma".

Jennifer Schneider **Greg Kosck**

In addition to these annual presentations, one **scholarship** was awarded to Greg Koscik of Oakland University.

Ha Dao **Mike Hardie)**

Ha Dao **Kush Shah**

The ASQ Automotive Division Chair, Ha Dao, presented 2 **Testimonial Awards**. One to Jay Zhou, the Division Membership Chair and incoming Treasurer (accepted by Mike Hardie), and to Kush Shah, the Division Vice Chair of the past two years and incoming Chair.

The ASQ Automotive Division also took time to recognize two new ASQ Fellows:

Lou Ann Lathrop of Chrysler and Jd Marhevko of JQLC.

Ha Dao **Lou Ann Lathrop**

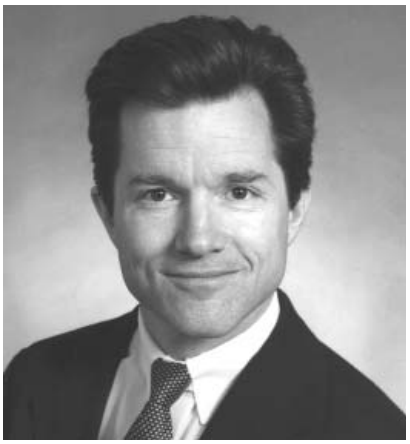
Ha Dao **Jd Marhevko**

Our thanks go out to the **Awards Committees** for their many hours spent in screening and selecting the award winners. If you have potential nominees for next year, please contact any of the committee chairs;

Jaynie Vize - Awards Chair
Chuck Tomlinson - Asst. Awards Chair
Carla Preston - Quality Professional Award
Carol Malone - Quality Leader
Larry Smith - Craig Award
Cheryl Denman - Koth Award
Harold Brubaker - Jarvis Service Award

Quantum Quality

by John Lindland



John Lindland

Introduction

This is the first of a three part article that will describe the newest and most powerful process improvement method in the world. Power is a measure of the amount of work that can be performed within a given amount of time. Six Sigma projects take six months or more to be completed. Quantum Quality Projects produce better results and are implementing solutions while Six Sigma is still trying to measure the process.

The author began his industrial quality applications in as a young engineer at Ford Motor Company. In 1985 he progressed through 8D problem Solving, Design of Experiments, The Seven Quality Tools, Kaizen, Lean, Failure Mode and Effects Analysis, and all the automotive core tools including the quality systems and quality systems auditing. He noticed that all improvement methods focus on one or more of three topics, wasted time, wasted work, and the causes of problems. He trained design of experiments at the Motorola University in the late 1980s. He has been a practicing Six Sigma Master Black Belt since 1995.

This first part of the article will cover the road that lead to discovering Quantum Quality. Then a short description of each of the four phases of Quantum Quality will be presented. The article will then cover a solid overview of Phase 1 of Quantum Quality, The Macro FMEA. The remaining three phases will be covered in the following two editions of Automotive Excellence.

The discovery of Quantum Quality

The basic framework for Quantum Quality began in 1991 with a training document called process based management. This quickly became error proofing and mistake proofing. By that time, the author had worked with a large number of problems solving teams and setup and analyzed hundreds of designed experiments. He also worked with a large number of teams to perform a large number of Process Failure Mode and Effects Analysis and mistake/error proofing. He found that when root cause analysis was performed at on each operation, the root analysis produced better results. He later started to perform root cause analysis on every action and energy transfer that produced a product or assembly and the analysis became a laser beam. Causes for each action/energy were normally very specific and were normally five or less in number. The causes could be identified very rapidly.

Anyone who has ever been involved in performing PFMEAs has found that the same cause is repeated many times and that the cause normally has the same prevention and occurrence number. They have also found that the same effects are found many times in the analysis and that the effect always has the same severity number. Along with these two phenomena every process has a finite number of in-line gages and inspection and testing strategies. All failure modes in the analysis use this short list of detection and control strategies. In fact, half way through a PFMEA very few new causes and effects are found. It becomes an exercise of cutting and pasting. The end result is that a team might produce a fifty page FMEA that contains two or three pages of unique information.

A new way to analyze PFMEA was created as the author continued to practice error proofing. While working with the United States Army to error proof the design and manufacturing of tank munitions, it was essential to evaluate every action of the process. This was termed to be a micro action analysis and a root cause analysis was performed on each micro action. The laser beam became brighter and more powerful. At that level, the descriptions of errors started to form consistent and repeatable categories. The author found seven errors that describe every way that an individual action could fail.

In the spring of 2000, Automotive Excellence published the first of a three part article on mistake proofing using these seven errors and examples of solutions for most of the errors. The work that started with the US Army became an entirely new way to perform root cause analysis. During this time frame, the author rewrote a set of training materials on PFMEA and found that the seven errors were also the seven failure modes and a new method for performing PFMEA was created. Each failure mode has a finite number of causes and a finite number of effects. The team never had to argue about what was a failure mode. This made it easy and fast to identify potential causes and potential effects. As soon as all the correct actions and energy transfers were identified all potential failure modes were also known. In less than sixty seconds a team could write down all seven potential failure modes and cross off any that were silly or improbable. This approach was continually improved and eventually produced a book by the author called, "The Seven Failure Modes" which was published in 2008. The first production run of "The Seven Failure Modes" sold out with the exception of copies that were given to the author. The next production run is scheduled for February 2012.

The last chapter of The Seven Failure Modes described an improvement method called Process Based Management. This is the same set of notes that started in 1991. Every year the author would take all his best discoveries and place them in this training manual. In an earlier form of Process Based Management, Ford Cleaveland Casting reduced their expenses by $110,000,000 over a three year period. The process described in "The Seven Failure Modes" is a four step process. It also described the possibility of have a single page PMFEA that would contain 100% of all FMEA information in a more useful format. After doing some research it was found that there were a large number of improvement methods around the world that were also called Process Based management. Some of them seem to be solid and similar to Six Sigma. The most notable is a method used by Boeing.

The author changed the method's name to Quantum Quality because it produces a fast and sudden change in quality and uses almost all new methods and tools. One of the definitions of Quantum is discrete quantities of energy with nothing in between. Quantum in the sense of this method is to produce sudden improvements in quality (not continuous). There are three tools in Quantum Quality that are adaptations and improvements from previous tools.

Quantum Quality *continued*

by John Lindland

One of the tools comes from QFD and a book called "Better Designs in Half the Time," by Bob King. Mr. King's book shows how powerful the relational matrix can be in making decisions. The Macro PFMEA and it resembles QFD as far as the 9, 3, 1 scoring of the relational matrix. The left side, roof, right side, and bottom of the analysis are classical PFMEA topics. The second tool that Quantum Quality modified is the Cause and Effect matrix that the author first learned to use in the mid 1980's. Six Sigma also makes great use of this tool. However, the method of determining cause and effect described in the book, "The Seven Failure Modes" provides the most structured, complete, and quickest cause an effect analysis possible. The only causes and effects that this process misses are outside the body of knowledge of the members involved in the analysis. Eighty to ninety-five percent of all causes and effects will be found through this analysis. If the team is experienced, ninety-five percent can be documented and structured. The five percent that will be missed either have not yet happened or have not happened in the collective time the team members have been working. The third tool is the SIPOC flow diagram which is used as the Macro Level Flow Diagram in Phase 1. This tool is modified with specific instructions for identifying inputs as conditions for success and outputs as intended outputs.

The current methods of Quantum Quality were recently applied to the launch of Ford Motor Company's 6R140 automatic transmission. The complete process was analyzed and solutions were applied to the new process before launch. The transmission launched with almost zero warranty and the internal poor quality produced was among the lowest in the plant. Tooling costs were 35% lower than comparable processes. The methods were then applied across the plant on all processes.

The author has been asked why 5S and Lean methods have not been included in Quantum Quality and the answer is simple. They are great tools in their own right. They each have their own objectives, which are honorable and desirable. They each have their own very fast timeline. They should be applied to every process and every operation. For example, lean manufacturing can complete value stream in a few hours. It might take a few days to fill in some of the knowledge gaps. Solutions can be implemented a few days later and control of the solution can be achieved within a few weeks. 5S is another great process. The first three steps of 5S can be applied in three to six hours. The forth step can be applied within one day. It can take three to four weeks to gain control of the fourth step. The forth step deals with leadership and makes sure that everyone knows what to do (Standardize, procedures, train to procedures). The fifth step (Sustain) is a function of discipline and good management. The executive manager of an operation needs to make sure that all his or her direct reports manage all their employees to established processes. This can take months or years to improve.

The four phases of Quantum Quality

There are four phases of Quantum Quality. Phase 1 the Macro PFMEA, Phase 2 Process and Product Metrics, Phase 3 Micro PFMEA, and Phase 4 Solutions. Phase 1 can normally be completed in a single eight to ten hour workshop. Phase 2 and 3 are started at the same time and run parallel with each other. Phase 2 is often completed after solutions have been found and implemented and this is okay. Phase 2 offers many new thoughts on the effective running of a business, quality, and when to use data to confirm cause and effect and when to simply move forward and implement a solution. Phase 2 assignments are normally delegated to employees who are not actively on a Quantum Quality team. This is an assignment that is similar to a PPAP (Production Part Approval Process) submission. Important input/function, noise metrics (the independent variable x in $y=f(x)$) and intended outputs (the dependent y) are measured and the results are given to the team for consideration and evaluation. Gauge capabilities are also confirmed. When problems with out of spec parts or non-capable gages are found, assignments are given to those who have control of the input, function, noise factor, or gage. Objective evidence of improvement is required to close the assignment. Phase 2 can take several weeks to complete and it will contain its own problems found and solutions rendered.

Every operation in a process receives its own Phase 3 and Phase 4 analysis. A rational prioritized plan of attack is identified in Phase 1. Phase 3 can usually be completed in two to six hours. Phase 4 can be completed in two to three hours to define technical solutions and the risk reduction of the solution. However, all solutions are not implemented and those that are might take a few days to weeks or longer depending on cost and delivery of solution constraints. It is rare that 50% of the solutions are implemented before quality improvement goals are achieved. It is easy to understand that solutions might be found before data exists to confirm cause and effect. Phase 4 offers a simple thought process for when to confirm cause and effect and when it is required. When a suggested solution is solid and inexpensive, confirming root cause might cost more than the solution. For example, adding a position sensor to make sure that a part is correctly in place (cause solution) before a cycle can start. When the solution is expensive, cause and effect really should be confirmed statistically. Also consider how difficult it is to confirm cause and effect for a cause. What if a process only produces 5 ppm defects? It would be statistically impractical to set up a confirmation study. In the case where a company produces a total 50 ppm and they are trying to achieve a goal of 3 ppm total defects, all solutions will be for causes that happen so rarely that confirming them all but impossible, in a practical sense. More simply stated, when the starting quality is fairly good (50-500 ppm), teams will need to implement solutions based on their best judgment because proving cause and effect will cost too much money.

Phase 1 The Macro Matrix FMEA

As Steven Covey says, begin with the end in mind. Phase 1 produces a one page matrix PFMEA that is considered to be at the macro level. The Macro Matrix PFMEA is produces a complete set of information for a standard PFMEA. However, the tools used to produce this matrix produce a much finer and higher quality FMEA than is produced using the older methods. It should be noted that this matrix can be used to quickly fill in a standard multipage PFMEA. All the information needed is produced and available.

Phase 1 produces the matrix shown in Figure 1. The rows are used to document all process inputs, process functions, and noise factors. The columns document all known intended and unintended outputs of the process. The matrix is scored the column and row totals provide prioritization for decisions.

Quantum Quality *continued*

by John Lindland

The sequences of events that will be detailed in the rest of this article are as follows. First the inputs are documented. Second, the process functions/actions that produce the intended outputs are defined (at least one for each intended output). Third, the unintended outputs are documented and related to specific failure modes. Forth, the rows and columns of the matrix are filled or populated. Fifth, the 9, 3, 1 relationships are identified and the rows and column totals are calculated. Sixth, the preventive actions currently used are written on the matrix and the detection strategies currently used are written on the matrix. Lastly, the PFMEA Severity, Occurrence, and Detection numbers are added. The Matrix PFMEAs are now ready for their initial review and prioritization of assignments. Phases 2, 3, and 4 are planned specific teams are formed.

Figure 1

The first tool used is a Process Definition Worksheet. This tool does not produce a clear picture of the process, its inputs, its intended outputs, or the unintended outputs. It is used to get the team thinking. There are tools that will follow that will continue to sharpen the analysis. This is a tool that some team members will want to skip. Until all team members are expert in the use of the tools, this step should not be skipped. The most important result of this tool is to define the scope of the analysis, the operations to be studied, starting list of inputs, intended outputs, and unintended outputs. Inputs include anything that directly touches a part or assembly, including the equipment or employee that controls that which touches the part. Intended outputs are all dimensions and material characteristics that a part or assembly must satisfy. Unintended outputs include all internal and external defects or descriptions of poor quality.

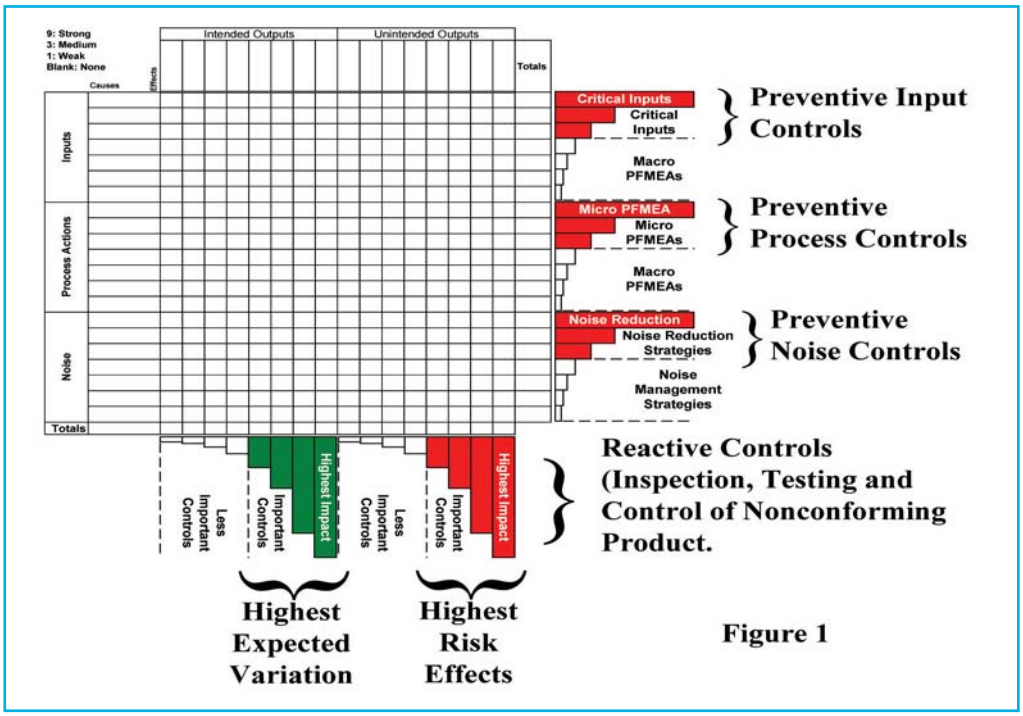
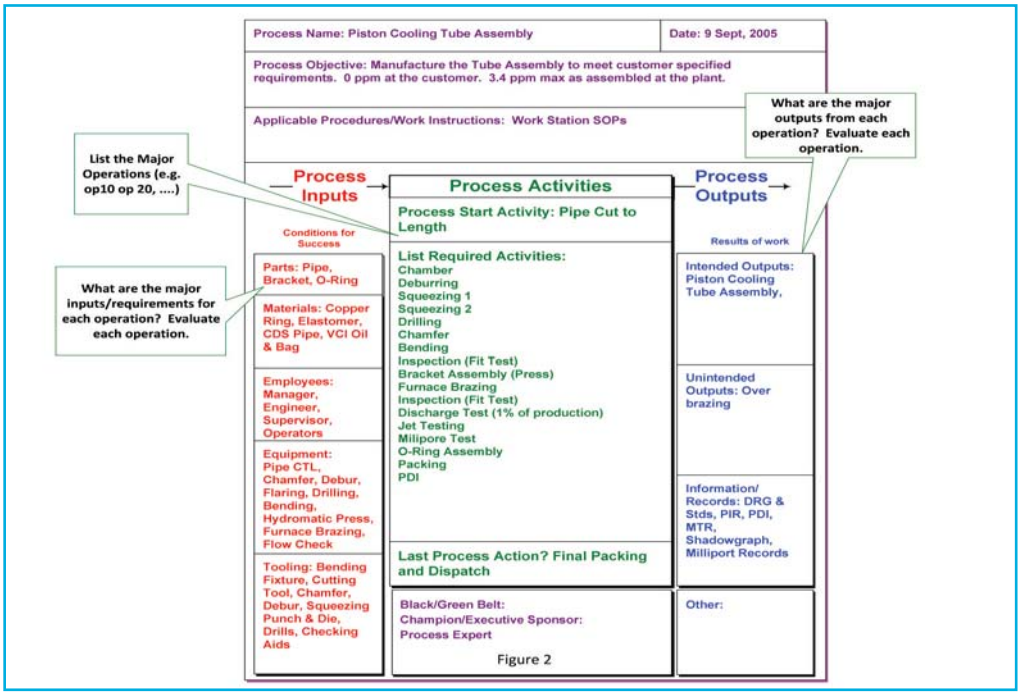


Figure 2 and 3

The next tool that is used is the Macro Process Flow Diagram (Figure 3). This is where structure begins to enter the analysis. Each operation is detailed in the middle of the form. One operation per block on the left/right. At each operation, the inputs that touch the part/assembly are documented. This includes employees, tools, materials, liquids, parts that enter the step under consideration, and machines. Each operation produces specific results. These are the intended outputs and they are documented on to the right of the operation description. The left most column identifies those who control the inputs and the right most column identifies those who receive the intended outputs. When metric problems relating to the inputs occur, the assignment to fix the input goes to the person responsible for the input. Unintended output information comes from those who receive the intended outputs.



Quantum Quality *continued*

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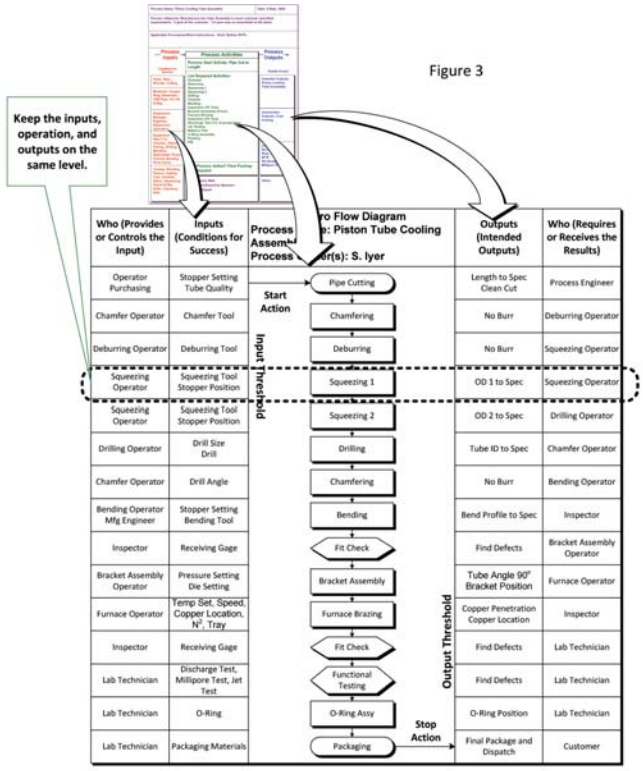


	Process Inputs	Adjective Noun	Specification
Inputs (Adjective-Noun)	Pipe	Correct Pipe	Engineering Spec
	Chamfer Tool 1	Sharp Tool	Less than 2000 parts
	Debur Tool	Sharp Tool	Less than 10,000 parts
	Squeezing Tool	Correct Tool	Correct tool number
	Drill	Correct Drill Size	Per Setup Sheet
	Chamfer Tool 2	Sharp Tool	Less than 2000 parts
	Bending Tool	Correct Angle	Correct as per tool room
		Correct Orientation	Correct as per tool room
	Bracket Press Tool	Tight Fit	Bracket press spec
		Correct Angle	90 Degrees
	Brazing Furnace Setup	Correct Setup	Setup Sheet
	Copper Wire	Correct Wire	Engineering Spec
	Tray	Correct Tray	Per Setup Sheet
	Temp/Cycle Time	Correct Temp	Per Setup Sheet
		Correct Time	Per Setup Sheet
	Fitiment Gauge	Correct Gauge	Process Control Plan
	Discharge Checking (Beaker)	Low Contamination	Less than 4 ppm

Figure 4

Figure 4

Once the macro flow diagram has been completed, the next step is to document and clarify the process inputs. A simple form can be created in MS-Excel (Figure 4) to assist in this analysis. Process inputs are qualified by their availability and quality. Both availability and quality can be defined through and adjective-noun relationship which describes the quality of the input. When the condition of the input also has a specification that must be met, the specification is identified. It is a good idea to have documented and measurable requirements for all inputs. Adjective-Noun examples include Good Parts (with specification that document which dimensions or characteristics make a good part), Good tool (with documented specifications that make a good tool), Correct Quantity, Correct Material, Competent Employees (Competent: The ability to perform a task correctly within a stated time limit), Maintained Equipment, etc.

Figure 5

The next step in the analysis is to document the process functions and their intended outputs. Process Functions are stated in a verb-noun format. At this level of analysis, all process functions are actually a summary description of many micro actions. For example, torque bolt is a summary of the following actions: engage threads, engage tool, turn bolt, achieve bottom, achieve turning force/torque (an alternate measure of strain) remove tool. Phase 3 will analyze the micro level. Phase 1 analyzes the macro level. Every intended output must have at least one function. Sometimes a process function creates several dimensions at once. For example, a dovetail cutting tool creates a profile of dimensions on a single pass. The tool has two primary functions, remove material and move distance. One is an energy function and the other is a movement function. A third function might be related to feed rate and time. When a multi spindle machine is used to create dimensions, every dimension has its own specific function to create a dimension or profile (intended output). Figure 5 shows another easy to create MS-Excel spreadsheet form.

The next part of the analysis considers the Unintended Outputs. Unintended outputs are the descriptions of defects and poor quality that are experienced internally at your location, externally at a customer location (other manufacturing/assembly), and by the user of your product (the ultimate customer). These are also the effects that are detailed on the PFMEA. Unintended outputs include:

- defective parts
- The effect that a defect creates when it is assembled to another part (problems of interface)
- The effect that the defect has on a system.
- The effect experienced by another assembly or manufacturing company who receives the part or assembly that includes the defective part
- The effect created by the defective part as experienced by the customer

Sources of data for unintended outputs include:

- internal records of defects (use similar parts if necessary)
- customer complaints
- warranty data
- research data
- reliability data

Quantum Quality *continued*

by John Lindland

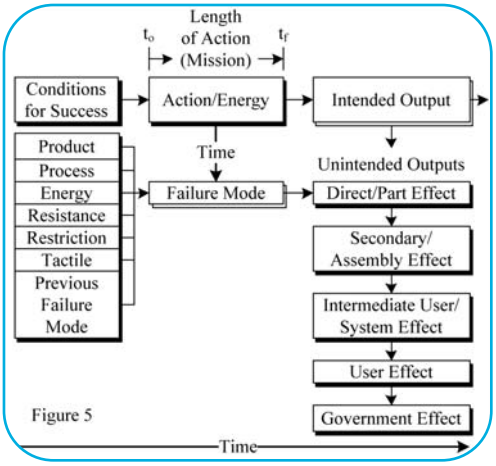


Figure 5

Intended outputs relate to achieving specified requirements. Unintended outputs occur when inputs are of poor quality, process functions operate outside the window of capability, or a noise factor directly impacts a part. They relate to the negative effect that occurs to the part, the interface between parts, the effect on the assembly, the effect on a system, and the affect noticed by the customer. The customer rarely notices a defective part. The customer normally notices a sound, feeling (vibration), smell, or a response (fast/slow). It is important to understand how intended outputs relate to unintended outputs. The macro matrix FMEA is used to accomplish this. Intended outputs can be predictors of internal unintended outputs and external (customer experienced) unintended outputs. Understanding the time sequence of the inputs, process actions and intended outputs (and the resulting unintended outputs) can be seen from figures 5 and 6. In figure 5 the unintended output is first seen on a part. The next opportunity is the interface between the defect on a part and its interface with another part and the assembled part (e.g. leak or poor orientation). Then the defect might show up as a system effect, intermediate user effect (automotive assembly plant), the user effect (loud noise, oil on the ground), or a violation of a government regulation. Each of the time related unintended outputs that occur must be documented.

Figure 6 and 7

Figure 6 shows an actual time sequence evaluation of the unintended outputs. The unintended outputs (effects) can be placed in a MS-Excel spreadsheet and ordered by time and grouped by functional relationship. This will be especially helpful when a PFMEA analysis is performed. Every time the effect on the part is noted in the analysis, the other related effects will also be known. What this means is that detection controls must be placed at the earliest internal unintended output point in a process flow. This would control/contain all following unintended outputs. It is why one detection strategy is so often used for many unintended outputs.

The unintended outputs come from internal and external records as well as the matrix which relates process function (verb-noun) and potential failure modes to the unintended outputs.

Figure 6 shows why it is important to ask how an internal defect can progress to other descriptions of unintended outputs. In the first analysis, the team missed all the customer related effects. The next unique tool that is used related the unintended outputs from figure 6 to specific functions (columns) and failure modes (rows). To accomplish this, the team must list the process functions n the order that they are performed. They must also have a list of all known unintended outputs. Figure 7 has all seven failure modes for each function. The seven failure modes are Omission, Excessive Action, Incomplete Action, Erratic Action (not stable/predictable), Uneven Action (Stable/Repeatable - action or energy is unevenly applied), Too Slow (action/energy related to time), and Too Slow.

Effect on Part	Effect on Assembly	Secondary Assembly Effect	Effect on Performance	Effect On System	Effect on Customer
Angle Variation	Not Perpendicular		Flow Off Target	Engine Damage	Engine Won't Start
Damaged Pipe			Poor Quality Spray	Engine Damage	Vehicle Stops Working
Sharp Edges			Poor Quality Spray	Engine Damage	
Uneven Chamfer			Poor Quality Spray	Engine Damage	
Partial Blockage			Low Fluid Volume		
Stepped ID	Interference Fit	Cannot Assemble	Weak Joint	Fails in Engine	Engine Won't Start
				Engine Damage	Vehicle Stops Working
Large OD	Interference Fit	Cannot Assemble			
Small OD	Not Perpendicular	Bracket Falls Off			
Uneven Length					
Missing O-ring			Low Fluid Volume	Engine Damage	Engine Won't Start
					Vehicle Stops Working
Nozzle too Short					

Figure 6 — Missing in First Analysis

Failure Modes	Intended Process Functions (Verb-Noun)									
	Cut Pipe	Chamfer Pipe	Remove Burr	Reduce Pipe	Size Pipe	Drill Hole	Bend Tube	Position Bracket	Braze Bracket	Assemble O-Ring
	Unexpected Outputs									
Omission	N/A	Sharp Edge	Sharp Edge, Poor Quality Spray, Partial Blockage	Damaged Pipe	OD Too Large	ID Variation, Low Fluid Volume, Poor Quality Spray	N/A	N/A	Bracket Falls Off	Missing O-Ring
Excessive	N/A	Large OD at End	Large OD at End	OD Too Small	OD Too Small	ID Variation, High Fluid Volume	Excessive Bends, Flow Off Target, Cannot Assemble	N/A	Overflow, Interference Fit	N/A
Incomplete	Sharp Edge, Uneven Length	Burr, Sharp Edge	Burr, Sharp Edge, Poor Quality Spray	Damaged Pipe	Nozzle Profile too Short	Stepped ID, Poor Quality Spray	Incomplete Bend Flow Off Target, Cannot Assemble	Position Variation, Not Perpendicular	Weak Joint	O-Ring Out of Position
Erratic	Rough Cut	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	O-Ring Out of Position
Uneven	Laceration Defect	Uneven Chamfer	Uneven Chamfer	N/A	N/A	Flow Off Target	N/A	N/A	Weak Joint	O-Ring Out of Position
Too Slow	Burr	N/A	N/A	Excessive Tool Wear	Length Variation	Burr	Angle Variation	Incomplete Assembly	N/A	N/A
Too Fast	N/A	N/A	N/A	N/A	Excessive Material Reduction	N/A	Angle Variation	N/A	N/A	N/A

Note: Off Target and Poor Quality Spray Can Lead to Engine Damage (Total Failure of Engine)

Figure 7

Quantum Quality *continued*

by John Lindland

The failure modes are now all defined and they are related to unintended outputs (effects). Figure 7 can be used a second time. Every cell that contains unintended outputs identifies the effects of the failure mode has specific causes that created the failure mode. Use a second form and write in all the causes that produce the failure mode. The first form has the unintended outputs and the second form has all the causes. Most of the causes describe the inputs that were of bad quality. Some causes will be unique and will not relate directly to inputs. This step can be completed in 45 to 90 minutes for both causes and effects for most process studies.

The final pieces of information that must be found before the Macro PFMEA can be completed are the noise factors. Noise factors are different energy sources, resistance, restrictions, and other sources that have an impact on the process action or energy transfer. Noise factors are potential causes of failure modes and unexpected outputs. This information will become important in the root cause/PFMEA analysis. Some noise factors for the process might be controlled at another process but not the process you are studying. For example, dirt is control for a clean room but it is likely to be a noise factor for a forging operation. One process operation might use controls, and another operation might not have the same controls developed. Noise factors may be controllable, but are currently not controlled. Example: Part to part variation might cause a shift in the process and yet still be well within specification (rubber, metal, plastic, high/low side of dimensions).

Each manufacturing and assembly plant will have their own list of common noise factors. They need to document these and provide a form to the team for their use at this step. An example of one such form is shown in Figure 8. Notice that the process functions are again in the top row. The noise factors that impact the function are described in the body of the form.

	Functions									
Noise Factors	**Cut Pipe**	**Chamfer Pipe**	**Remove Burr**	**Reduce Pipe**	**Size Pipe**	**Drill Hole**	**Bend Tube**	**Position Bracket**	**Braze Bracket**	**Assemble O-Ring**
Part to Part Variation									Variation in location of copper	
Dirt and Contamination								Buildup in Nest	Oil on tube and bracket	
Setups	Length setup difficult	No depth control	No depth control							
Tooling/Tool Changes	Tool adjustments are difficult	Tool adjustments are difficult	Tool adjustments are difficult	Tool adjustments are difficult	Tool adjustments are difficult	Number of parts not controlled				
Human Tactile				Operator Incomplete Actions	Operator Incomplete Actions					
Equipment Changes/Wear				Entire setup, change difficult	Entire setup, change difficult	Drill wears and breaks				
Fixtures										
Environmental Factors										
Adjustments										
Temperature	Tool temp too high, not cooled	Tool gets hot and breaks	Tool gets hot and breaks	Hot tool size gets larger	Hot tool size gets larger		High temp-bend variation			
Humidity										
External Vibration	Machine vibrates	Machine vibrates	Machine vibrates	Mach vib into part variation	Mach vib into part variation	Mach vib into part variation				
Weak Foundation										
Mechanical Shock from Loading										
Plant Air Quality										
Plant Water (dirt contamination)										
Plant Power (spikes/phase angle)	Frequent elect pwr failure	Frequent elect pwr failure	Frequent elect pwr failure	Frequent elect pwr failure	Frequent elect pwr failure	Frequent elect pwr failure	Frequent elect pwr failure	Frequent elect pwr failure	Frequent elect pwr failure	
Plant Maintenance										
Weld Slag										
EM Field										

Figure 8

Enough information exists now to begin building the Macro Matrix PFMEA. This analysis provides a very powerful measure of the relationships between the controlling factors and the outputs. Variation of the inputs, process actions, and noise factors can all create variation in the intended and unintended outputs. The inputs, process actions, and noise factors are causes and the outputs are the effects (intended and unintended outputs). When the team thinks that there may be a strong relationship between the cause and effect they score the relationship as a 9. Mediums receive a 3 and weak receive a 1. Two medium relationships do not equal a strong relationship (3+3=6 not 9). Two weak relationships do not equal a medium relationship (1+1=2 not 3).

In the function formula y=f(x), the rows are the independent x variables and the columns are the dependent y variables, y. A score of 9, 3, or 1 in a cell means that there is a cause, failure mode (the function) effect relationship.

This is where the team describes how the intended outputs are produced (9 and 3 relations) and how the unintended outputs are produced. Figure 7 provides useful information in documenting the 9, 3, 1 relationships for the process functions. The inputs, process actions, and noise factors that have the largest row totals have the strongest relationship to creating planned or unplanned outputs.

Quantum Quality *continued*

by John Lindland

Make sure that solid process controls are, documented with clear
responsibilities, in place, and managed for the larger controlling inputs, process actions, and noise factors. Most of the smaller rows can be managed through periodic controls. The Controls are called preventions and this means managing the conditions for success. Each row will have a frequency of occurrence (mean time between failure) by where the conditions become of poor quality.

For the simplicity of this article, the author will assume that all readers have a copy of the AIAG FMEA reference manual. This document has tables that can be used to determine Severity, Occurrence, and Detection risks. Risk numbers range from 1 (very small risk) to 10 very large risk. Figure 9 shows the relationships of where risk numbers are placed on the matrix. The relationship matrix will produce two PFMEAs, the SO PFMEA and the SOD (RPN=SOD) or the Risk Priority Number PFMEA. Severity risks are entered onto the form under the description of the unintended output. Occurrence risk numbers are entered in the column to the right of row totals. Detection risk numbers are entered in the row below the description of the detection method. The purpose of this article is to show the new tools and provide new thoughts, not to teach PFMEA. The book on Quantum Quality that the author is currently writing will present both the new tools and how to perform matrix PFMEA studies.

The author has designed linked MS-Excel spreadsheets that feed each other. When the relational matrix is filled out, the SO PFMEA and RPN PFMEA are automatically filled out and scored. For those who understand how to write a conditional formula, when a cell has a 9, 3, or a 1, the S column and O row cells are multiplied and placed in the appropriate cell on the PFMEA. In use, the equations always get messed up and have to be recopied as the team adds and deletes rows and columns on the relational matrix. Once the equations have been written, fixing the equations only takes a few minutes.

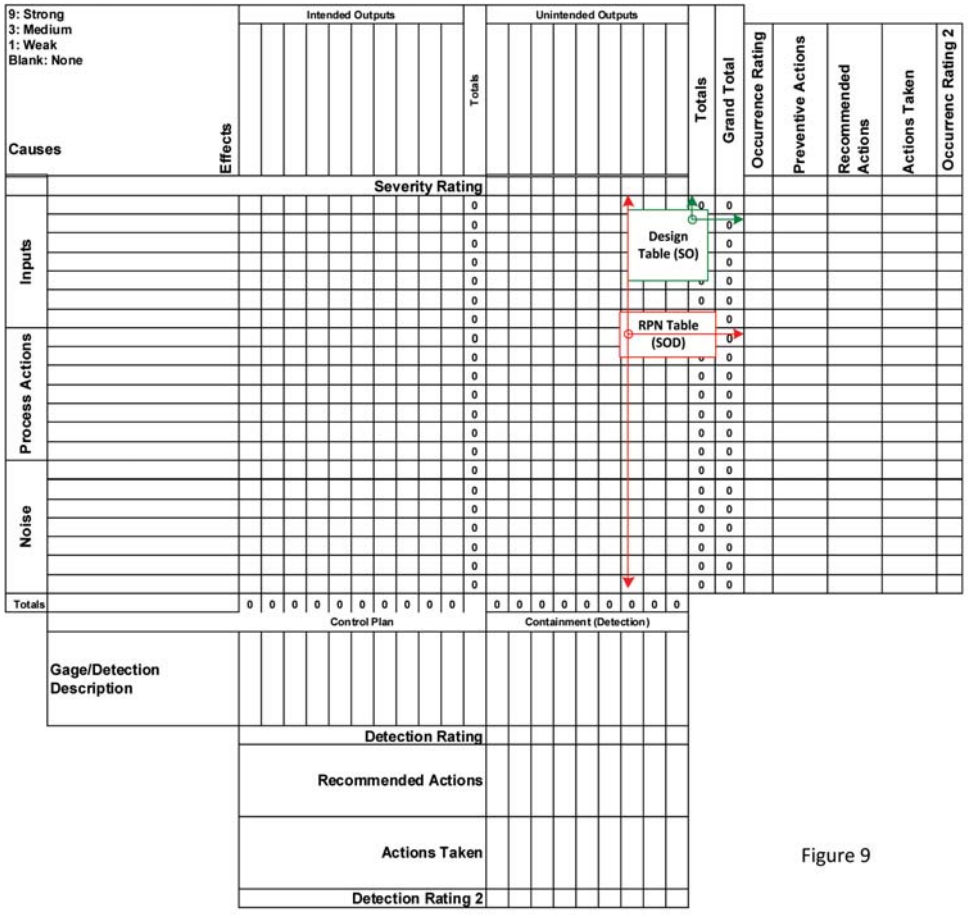


Figure 9

Figure 10

Figure 10 shows an example of a completed relational matrix PFMEA. In the spreadsheet that the author uses, all the PFMEA risk numbers, control plans, detection plans, preventions and risk number are added to this form and automatically copied to the actual Matrix PFMEAs. The reader can spend some time reading the form and make up their own mind as to the clarity of the results. This is a real study that was performed stat to stop with a client in India. Poor quality of the entire process went from 10% to 15 ppm within six weeks. The product was a fairly simple engine piston cooling nozzle.

The preventions that are written on Figure 10 are only those that were currently being performed. Preventions that are written on the form must be in place, documented, and managed to be written on the form. Preventions are not the soft skills that could be carried out. They are what are actually being performed. It is important to imp the top three inputs, setup gauges were created (prevention), the required competency (ability to complete a task correctly within specific amount of time) was documented, trained, and managed (prevention), and better tool controls were developed (5S workshop) and documented in the recommended actions row.

At the bottom of the matrix the gauges that are used to monitor the product and find defects are documented. Teams should take a look at the top few risky intended outputs and unintended outputs and improve the sampling and measurement strategy. If the unintended output is an external event (the product has left the building and been found by the customer), the internal unintended output that creates the external event must be assessed for improving the detection and containment strategy. The improved strategy is documented in the bottom of the column in the recommended actions section. All this can be done BEFORE the team looks at the RPN risks (SO and RPN) on the forms

Similar documented and implemented preventive actions were carried out for the most important process actions (functions) and noise factors.

Quantum Quality *continued*

by John Lindland

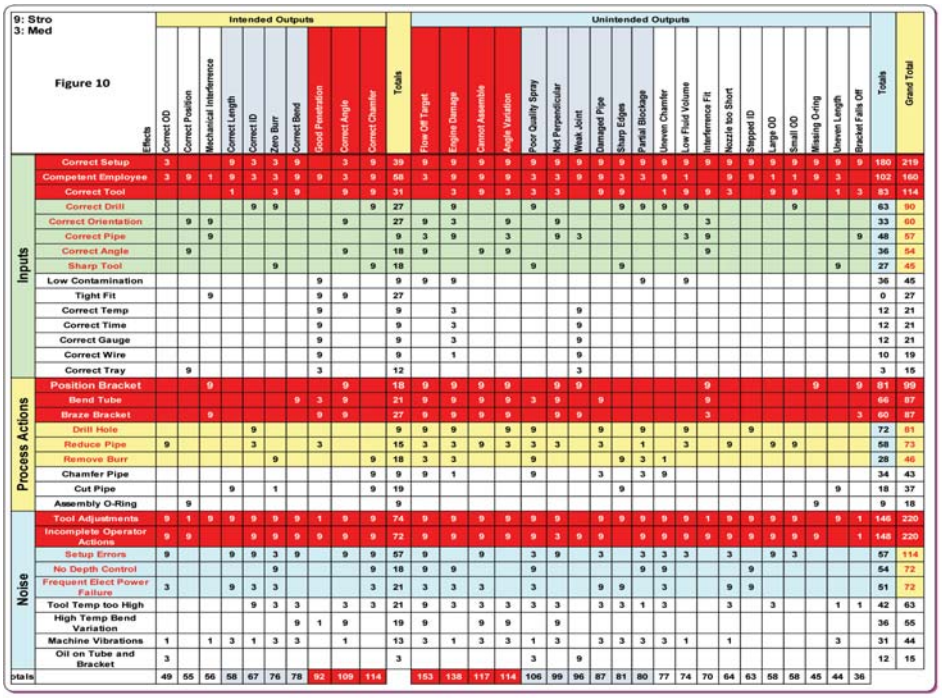


Figure 10

9: Stro 3: Med	Effects	Intended Outputs: Correct OD	Correct Position	Mechanical Interference	Correct Length	Correct ID	Zero Burr	Correct Bend	Good Penetration	Correct Angle	Correct Chamfer	Totals	Unintended Outputs: Flow Off Target	Engine Damage	Cannot Assemble	Angle Variation	Poor Quality Spray	Not Perpendicular	Weak Joint	Damaged Pipe	Sharp Edges	Partial Blockage	Uneven Chamfer	Low Fluid Volume	Interference Fit	Nozzle too Short	Stepped ID	Large OD	Small OD	Missing O-ring	Uneven Length	Bracket Falls Off	Totals	Grand Total
Inputs	Correct Setup	3			9	3	3	9		3	9	39	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	180	219
	Competent Employee	3	9	1	9	3	3	9	9	3	9	58	3	9	9	9	3	3	9	9	3	3	9	1		9	9	1	1	9	3	102	160
	Correct Tool				1		3	9		9	9	31		3	9	3	3	3		9	9		1	9	9	3		9	9		1	3	83	114
	Correct Drill					9	9				9	27		9			9				9	9	9	9					9			63	90
	Correct Orientation		9	9						9		27	9	3		9		9						3								33	60
	Correct Pipe			9								9	3	9		3		9	3					3	9						9	48	57
	Correct Angle		9							9		18	9		9	9									9							36	54
	Sharp Tool						9				9	18					9				9									9		27	45
	Low Contamination								9			9	9	9								9		9								36	45
	Tight Fit			9					9	9		27																				0	27
	Correct Temp								9			9		3					9														12	21
	Correct Time								9			9		3					9														12	21
	Correct Gauge								9			9		3					9														12	21
	Correct Wire								9			9		1					9														10	19
	Correct Tray		9						3			12							3														3	15
Process Actions	Position Bracket			9						9		18	9	9	9	9		9	9						9					9		9	81	99
	Bend Tube							9	3	9		21	9	9	9	9	3	9		9					9								66	87
	Braze Bracket			9					9	9		27	9	9	9	9		9	9						3							3	60	87
	Drill Hole					9						9	9	9			9	9			9		9				9						72	81
	Reduce Pipe	9				3			3			15	3	3	9	3	3	3		3		1		3		9		9	9			58	73
	Remove Burr						9				9	18	3	3			9				9	3	1										28	46
	Chamfer Pipe										9	9	9	1			9			3		3	9										34	43
	Cut Pipe				9		1				9	19									9									9			18	37
	Assembly O-Ring		9									9																	9			9	18
Noise	Tool Adjustments	9	1	9	9	9	9	9	1	9	9	74	9	9	9	9	9	9		9	9	9	9	9	1	9	9	9	9		9	1	146	220
	Incomplete Operator Actions	9	9			9	9	9	9	9	9	72	9	9	9	9	9	3	9	9		9	9	9	9	9	9	9	9	9		1	148	220
	Setup Errors	9			9	9	3	9		9	9	57	9		9		3	9		3		3	3	3		3		9	3				57	114
	No Depth Control						9				9	18	9	9			9					9	9				9						54	72
	Frequent Elect Power Failure	3			9	3	3				3	21	3	3	3		3			9	9		3			9	9						51	72
	Tool Temp too High					9	3	3		3	3	21	9	3	3	3	3			3	3	1	3			3		3			1	1	42	63
	High Temp Bend Variation							9	1	9		19	9		9	9			9														36	55
	Machine Vibrations	1		1	3	1	3	3		1		13	3	1	3	3	1	3		3	3	3	3	1		1				3		31	44
	Oil on Tube and Bracket	3										3					3		9													12	15
Totals		49	55	56	58	67	76	78	92	109	114		153	138	117	114	106	99	96	87	81	80	77	74	70	64	63	58	58	45	44	36		

Figure 11

Figure 11 shows an example of the Severity-Occurrence Macro Matrix PFMEA. The MS-Excel cells are coded such that when the SO number is 35 or greater, the cell color turns red. When the SO number is 35 or greater, the core process design is flawed and really needs to be physically modified. This means lowering the Occurrence number through technical improvements. Technical improvements will be covered in some detail in a later article when Phase 4 is covered. When Occurrence is reduced, capability is improved, and variation is also reduced. Teams need to look at the Totals of the rows for the SO numbers and prioritize which inputs, process actions, and noise factors are most important to fix first. Large row totals and rows that contain SO numbers that are greater than 34 should be prioritized for action first.

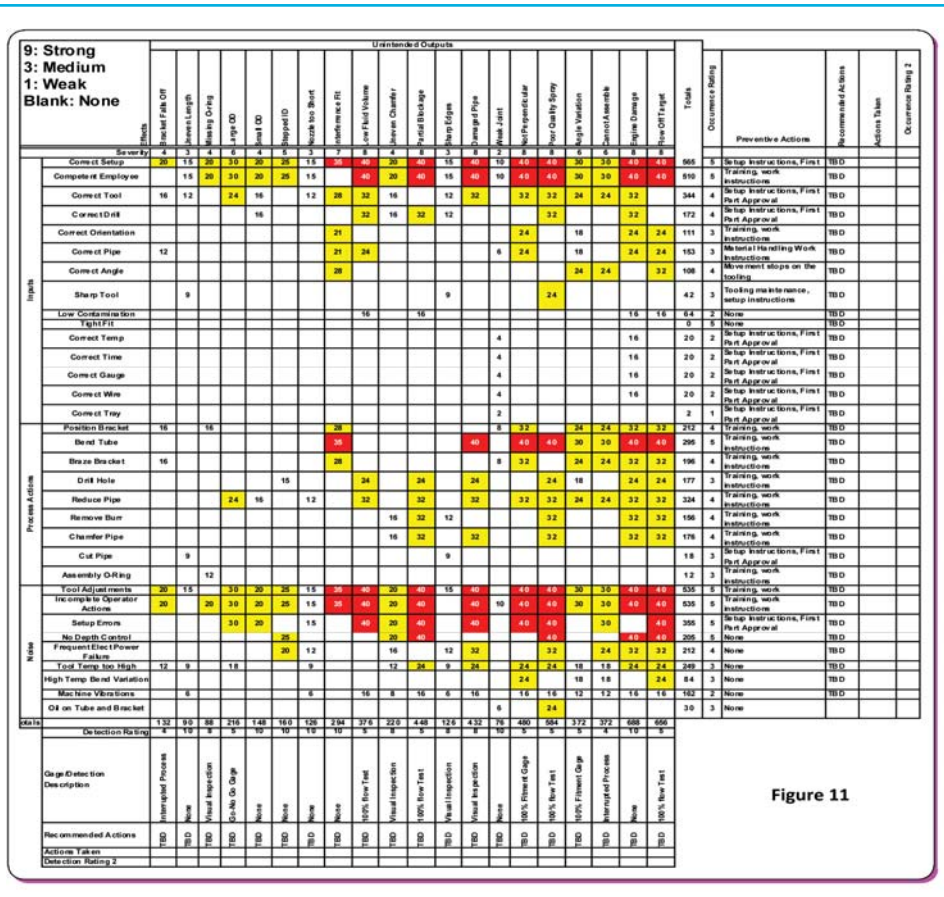


Figure 11

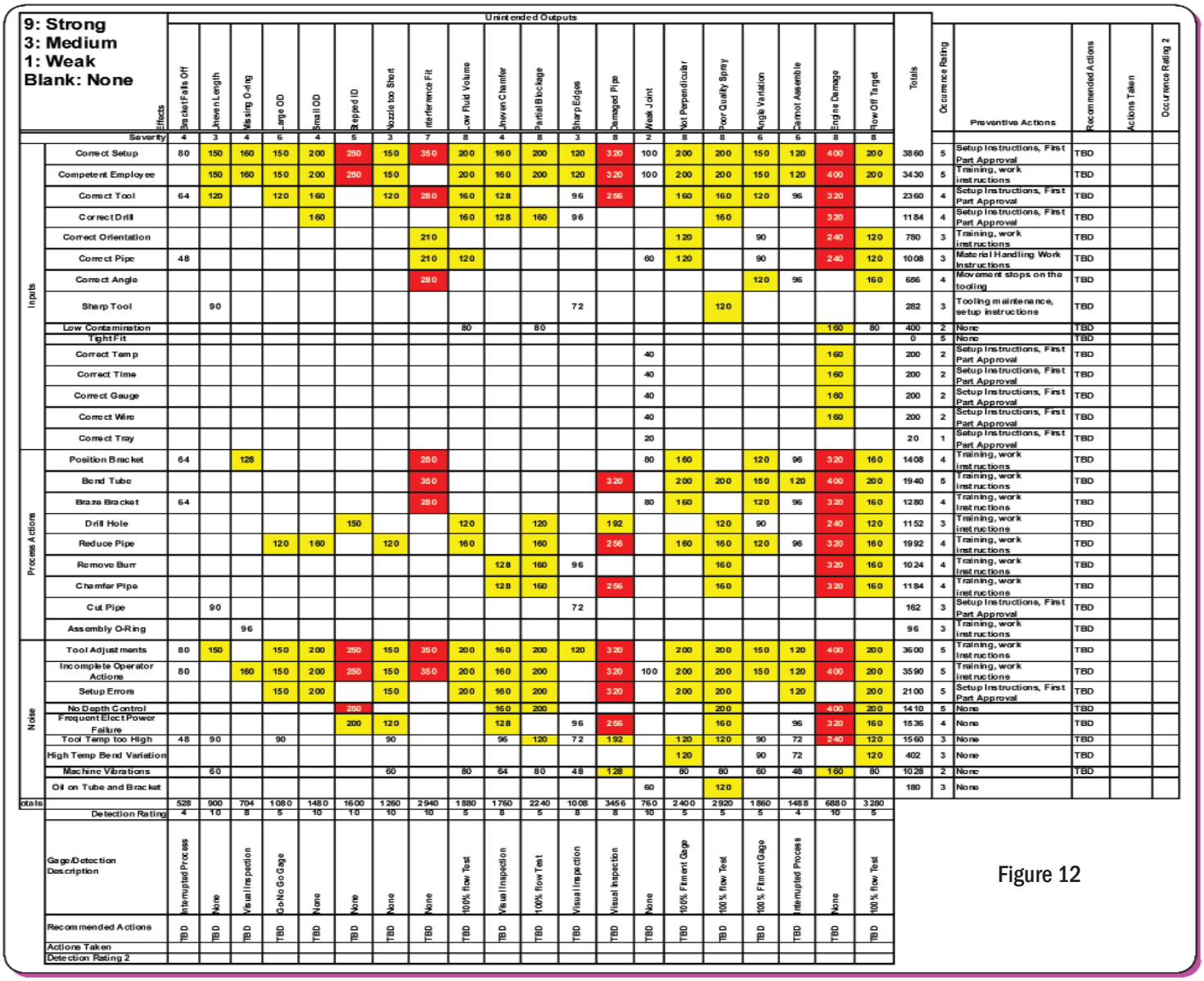
9: Strong 3: Medium 1: Weak Blank: None	Effects	Unintended Outputs: Bracket Falls Off	Uneven Length	Missing O-ring	Large OD	Small OD	Stepped ID	Nozzle too Short	Interference Fit	Low Fluid Volume	Uneven Chamfer	Partial Blockage	Sharp Edges	Damaged Pipe	Weak Joint	Not Perpendicular	Poor Quality Spray	Angle Variation	Cannot Assemble	Engine Damage	Flow Off Target	Totals	Occurrence Rating	Preventive Actions	Recommended Actions	Actions Taken	Occurrence Rating 2
	Severity	4	4	4	6	4	5	5	7	5	4	6	5	6	5	5	5	6	6	6	6						
Inputs	Correct Setup	20	15	20	30	20	25	15	35	40	20	40	15	40	10	40	40	30	30	40	40	565	5	Setup Instructions, First Part Approval	TBD		
	Competent Employee		15	20	30	20	25	15		40	20	40	15	40	10	40	40	30	30	40	40	510	5	Training, work instructions	TBD		
	Correct Tool	16	12		24	16		12	28	32	16		12	32		32	32	24	24	32		344	4	Setup Instructions, First Part Approval	TBD		
	Correct Drill					16				32	16	32	12				32			32		172	4	Setup Instructions, First Part Approval	TBD		
	Correct Orientation								21							24		18		24	24	111	3	Training, work instructions	TBD		
	Correct Pipe	12							21	24				6	24			18		24	24	153	3	Material Handling Work Instructions	TBD		
	Correct Angle								28									24	24		32	108	4	Movement slope on the tooling	TBD		
	Sharp Tool		9										9			24						42	3	Tooling maintenance, setup instructions	TBD		
	Low Contamination									16		16								16	16	64	2	None	TBD		
	Tight Fit																					0	5	None	TBD		
	Correct Temp														4					16		20	2	Setup Instructions, First Part Approval	TBD		
	Correct Time														4					16		20	2	Setup Instructions, First Part Approval	TBD		
	Correct Gauge														4					16		20	2	Setup Instructions, First Part Approval	TBD		
	Correct Wire														4					16		20	2	Setup Instructions, First Part Approval	TBD		
	Correct Tray														2							2	1	Setup Instructions, First Part Approval	TBD		
Process Actions	Position Bracket	16		16					28						8	32		24	24	32	32	212	4	Training, work instructions	TBD		
	Bend Tube								35					40		40	40	30	30	40	40	295	5	Training, work instructions	TBD		
	Braze Bracket	16							28						8	32		24	24	32	32	196	4	Training, work instructions	TBD		
	Drill Hole						15			24		24		24			24	18		24	24	177	3	Training, work instructions	TBD		
	Reduce Pipe				24	16		12		32		32		32		32	32	24	24	32	32	324	4	Training, work instructions	TBD		
	Remove Burr										16	32	12				32			32	32	156	4	Training, work instructions	TBD		
	Chamfer Pipe										16	32		32			32			32	32	176	4	Training, work instructions	TBD		
	Cut Pipe		9										9									18	3	Setup Instructions, First Part Approval	TBD		
	Assembly O-Ring			12																		12	2	Training, work instructions	TBD		
Noise	Tool Adjustments	20	15		30	20	25	15	35	40	20	40	15	40		40	40	30	30	40	40	535	5	Training, work instructions	TBD		
	Incomplete Operator Actions	20		20	30	20	25	15	35	40	20	40		40	10	40	40	30	30	40	40	535	5	Training, work instructions	TBD		
	Setup Errors				30	20		15		40	20	40		40		40	40		30		40	355	5	Setup Instructions, First Part Approval	TBD		
	No Depth Control						25				20	40					40			40	40	205	5	None	TBD		
	Frequent Elect Power Failure						20	12			16		12	32			32		24	32	32	212	4	None	TBD		
	Tool Temp too High	12	9		18			9			12	24	9	24		24	24	18	18	24	24	249	3	None	TBD		
	High Temp Bend Variation															24		18	18		24	84	3	None	TBD		
	Machine Vibrations		6					6		16	8	16	6	16		16	16	12	12	16	16	162	2	None	TBD		
	Oil on Tube and Bracket														6	24						30	3	None			
Totals		132	90	88	216	148	160	126	294	376	220	448	126	432	76	480	584	372	372	688	656						
	Detection Rating	4	10	8	5	10	10	10	10	5	8	5	8	8	10	5	5	5	4	10	5						
	Gage/Detection Description	Interrupted Process	None	Visual Inspection	Go-No Go Gage	None	None	None	None	100% Flow Test	Visual Inspection	100% Flow Test	Visual Inspection	Visual Inspection	None	100% Fitment Gage	100% Flow Test	100% Fitment Gage	Interrupted Process	None	100% Flow Test						
	Recommended Actions	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD						
	Actions Taken																										
	Detection Rating 2																										

Figure 12

Figure 12 shows the classic numbering for which PFMEA has become known, the RPN number. Only look at the RPN for making decisions after all occurrences have been reduced to the level that a company budget allows. RPNs are then reduced by purchasing and implementing a better gauge strategy. Occurrence creates internal and external cost of poor quality. Detection strategies have the goal of reducing external cost of poor quality and turning it into a lower internal cost of poor quality. It shifts the burden and is a professional choice. However, it is not quality. The customer experiences better quality but the producer is not making better quality. The cells are color coded such that any RPN that is below 120 is not shaded as a risk. RPNs that are 120-239 are shaded as moderate risks (yellow). High risk RPNs are 240 and over. When reducing RPNs, the team looks at improving detection. This is only considered after all occurrence numbers from the SO Matrix PFMEA have been addressed.

Quantum Quality *continued*

by John Lindland



9: Strong 3: Medium 1: Weak Blank: None		Unintended Outputs																									
	Effects	Bracket Falls Off	Uneven Length	Missing O-ring	Large OD	Small OD	Stepped ID	Nozzle too Short	Interference Fit	Low Fluid Volume	Uneven Chamfer	Partial Blockage	Sharp Edges	Damaged Pipe	Weak Joint	Not Perpendicular	Poor Quality Spray	Angle Variation	Cannot Assemble	Engine Damage	Flow Off Target	Totals	Occurrence Rating	Preventive Actions	Recommended Actions	Actions Taken	Occurrence Rating 2
	Severity	4	3	4	5	4	5	3	7	8	4	8	3	8	2	8	8	6	6	8	8						
Inputs	Correct Setup	80	150	160	150	200	250	150	350	200	160	200	120	320	100	200	200	150	120	400	200	3860	5	Setup Instructions, First Part Approval	TBD		
	Competent Employee		150	160	150	200	250	150		200	160	200	120	320	100	200	200	150	120	400	200	3430	5	Training, work instructions	TBD		
	Correct Tool	64	120		120	160		120	280	160	128		96	256		160	160	120	96	320		2360	4	Setup Instructions, First Part Approval	TBD		
	Correct Drill					160				160	128	160	96				160			320		1184	4	Setup Instructions, First Part Approval	TBD		
	Correct Orientation								210							120		90		240	120	780	3	Training, work instructions	TBD		
	Correct Pipe	48							210	120					60	120		90		240	120	1008	3	Material Handling Work Instructions	TBD		
	Correct Angle								280									120	96		160	656	4	Movement stops on the tooling	TBD		
	Sharp Tool		90										72				120					282	3	Tooling maintenance, setup instructions	TBD		
	Low Contamination									80		80								160	80	400	2	None	TBD		
	Tight Fit																					0	5	None	TBD		
	Correct Temp														40					160		200	2	Setup Instructions, First Part Approval	TBD		
	Correct Time														40					160		200	2	Setup Instructions, First Part Approval	TBD		
	Correct Gauge														40					160		200	2	Setup Instructions, First Part Approval	TBD		
	Correct Wire														40					160		200	2	Setup Instructions, First Part Approval	TBD		
	Correct Tray														20							20	1	Setup Instructions, First Part Approval	TBD		
Process Actions	Position Bracket	64		128					280						80	160		120	96	320	160	1408	4	Training, work instructions	TBD		
	Bend Tube								350					320		200	200	150	120	400	200	1940	5	Training, work instructions	TBD		
	Braze Bracket	64							280						80	160		120	96	320	160	1280	4	Training, work instructions	TBD		
	Drill Hole						150			120		120		192			120	90		240	120	1152	3	Training, work instructions	TBD		
	Reduce Pipe				120	160		120		160		160		256		160	160	120	96	320	160	1992	4	Training, work instructions	TBD		
	Remove Burr										128	160	96				160			320	160	1024	4	Training, work instructions	TBD		
	Chamfer Pipe										128	160		256			160			320	160	1184	4	Training, work instructions	TBD		
	Cut Pipe		90										72									162	3	Setup Instructions, First Part Approval	TBD		
	Assembly O-Ring			96																		96	3	Training, work instructions	TBD		
Noise	Tool Adjustments	80	150		150	200	250	150	350	200	160	200	120	320		200	200	150	120	400	200	3600	5	Training, work instructions	TBD		
	Incomplete Operator Actions	80		160	150	200	250	150	350	200	160	200		320	100	200	200	150	120	400	200	3590	5	Training, work instructions	TBD		
	Setup Errors				150	200		150		200	160	200		320		200	200		120		200	2100	5	Setup Instructions, First Part Approval	TBD		
	No Depth Control						250				160	200					200			400	200	1410	5	None	TBD		
	Frequent Elect Power Failure						200	120			128		96	256			160		96	320	160	1536	4	None	TBD		
	Tool Temp too High	48	90		90			90			96	120	72	192		120	120	90	72	240	120	1560	3	None	TBD		
	High Temp Bend Variation															120		90	72		120	402	3	None	TBD		
	Machine Vibrations		60					60		80	64	80	48	128		80	80	60	48	160	80	1028	2	None	TBD		
	Oil on Tube and Bracket														60		120					180	3	None			
Totals		528	900	704	1080	1480	1600	1260	2940	1880	1760	2240	1008	3456	760	2400	2920	1860	1488	6880	3280						
	Detection Rating	4	10	8	5	10	10	10	10	5	8	5	8	8	10	5	5	5	4	10	5						
	Gage/Detection Description	Interrupted Process	None	Visual Inspection	Go-No Go Gage	None	None	None	None	100% flow Test	Visual Inspection	100% flow Test	Visual Inspection	Visual Inspection	None	100% Fitment Gage	100% flow Test	100% Fitment Gage	Interrupted Process	None	100% flow Test						
	Recommended Actions	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD						
	Actions Taken																										
	Detection Rating 2																										

Figure 12

In summary, this article has covered the discovery of Quantum Quality and shown many new powerful tools that lead up to a completely new technology, the Matrix FMEA. The Macro Matrix FMEA is documented at the normal level of detail of most PFMEAs that are used to support PPAP. All the information on the causes failure modes and effects (the Macro Flow Diagram, RPN Matrix PFMEA, and a Figure 7 for each causes and effects) can be transferred to a multipage FMEA document very quickly. This approach can reduce the amount of time it takes to produce a solid PFMEA to hours rather than days.

The reader should critically consider the tools shown and compare the power of Phase 1 of Quantum Quality. Once the initial recommended actions for prevention and detection are achieved, 50% of all poor quality can normally be reduced just through better management of the conditions for success (recommended actions for most inputs, process actions, and noise factors).

The next two articles will cover Phase 2 (metrics), Phase 3 (Micro PFMEA), and Phase 4 (Improvements). The break point between the second and third article will be determined as the article progresses. The reader will continue to discover new powerful tools for process improvement. Stay tuned. Support your local ASQ Automotive Division. Should you have any questions please contact the author at jlindland@qualsat.com. The author is in the middle of writing a book on Quantum Quality. It should be available in January 2012. The second printing of "The Seven Failure Modes" is scheduled for February 2012.

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