

**TEN STEP**  
**MANUFACTURING PROBLEM SOLVING**  
**PROCESS**

by

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## **ABSTRACT**

The ten step problem solving is created to capture and resolve all issues that arise with designing, developing, manufacturing and delivering a new vehicle produce.

These steps will provide a common process, which effectively defines and resolves concerns and prevents their recurrence.

Step 1: Prepare for the process

Step 2: Establish Team

Step 3: Describe the Problem

Step 4: Develop short term containment action

Step 5: Define and verify root cause and escape point

Step 6: Choose and verify permanent corrective actions

Step 7: Implement and validate permanent corrective actions

Step 8: Prevent recurrence

Step 9: Recognize team and individual contributions

Step 10: Benchmarking

The ten step problem solving process is an enhancement to 6-sigma process that is currently used by many manufacturers.

Consumer Driven 6-Sigma is a tool that significantly improves customer satisfaction and shareholder value by reducing variability in every aspect of the business.

It builds on existing processes, provides additional tools, and offers a disciplined approach to focus on meeting customer expectations.

6-Sigma helps on finding out where the variability is in a process, and then provides the tools to reduce variability and make the process better.

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## **LIST OF ACRONYMS/ABBREVIATIONS**

SCA: Short term Containment Action

PCA: Permanent Corrective Action

# INTRODUCTION

The purpose of this thesis is to provide the general nine steps to solve manufacturing problems in order to build more reliable vehicles while increasing customer satisfaction.

These steps are created to capture and resolve all issues that arise with designing, developing, manufacturing and delivering a new vehicle produce.

These ten steps will provide a common process, which effectively defines and resolves concerns and prevents their recurrence.

Other benefits of these nine steps are increase management understanding, improve concern resolution and prevention, improve performance to quality/cost/timing, promote frank and open problem solving and provide automated computer support.

These steps require a specific team to work on the problem. The teams play a key role in their organizations by being empowered to find root causes, implement corrective actions, prevent any recurrence and recommend process improvements. These teams have the authority, responsibility, and accountability for solving the problem.

By identifying the symptom, implementing an Emergency Response Action, and protecting the short term and external customers from adverse effects of the problem, teams can resolve problems permanently and achieve customer satisfaction.

The 9 step problem solving process consists of following nine components:

Step 1: Prepare for the process. In response to a symptom, evaluate the need for the process. If necessary, provide an Emergency Response Action to protect the customer and initiate the 9 step process.

Step 2: Establish Team. Establish a small group of people with the process and/or product knowledge, allocated time, authority, and skill in the required technical disciplines to solve the problem and implement corrective actions. The group must have a designated champion and team leader. The group begins the team building process.

Step 3: Describe the Problem. Describe the internal/external customer Problem by identifying "what is wrong with what" and detail the Problem in quantifiable terms.

Step 4: Develop short term containment action (SCA) define, verify, and implement the short term containment action (SCA) to isolate effects of the problem from any internal/external customer until permanent corrective actions (PCAs) are implemented. Validate the effectiveness of the containment actions.

Step 5: Define and verify root cause and escape point. Isolate and verify the root cause by testing each possible cause against the problem description and test data. Also isolate and verify the place in the process where the effect of the root cause should have been detected and contained.

Step 6: Choose and verify permanent corrective actions for root cause and escape point select the best permanent corrective action to remove the root cause. Also select the best permanent corrective action to eliminate escape. Verify that both decisions will be successful when implemented without causing undesirable effects.

Step 7: Implement and validate permanent corrective actions. Plan and implement selected permanent corrective actions. Remove the interim containment action. Monitor the long-term results.

Step 8: Prevent recurrence. Modify the necessary systems including policies, practices, and procedures to prevent recurrence of this problem and similar ones. Make recommendations for systemic improvements, as necessary.

Step 9: Recognize team and individual contributions. Complete the team experience, sincerely recognize both team and individual contributions.

Step 10: Benchmarking: Benchmarking will provide opportunity to look at the same module on other similar vehicles to find the weak or strong point of our design.

## LITERATURE REVIEW

The ten step problem solving process is an enhancement of 6-sigma and global 8D process:

The following is a review of relevant problem solving process:

1: Ronald Leporte, professor: Six Sigma is a management philosophy developed by Motorola that emphasizes setting extremely high objectives, collecting data, and analyzing results to a fine degree as a way to reduce defects in products and services. The Greek letter *sigma* is sometimes used to denote variation from a standard. The philosophy behind Six Sigma is that if you measure how many defects are in a process, you can figure out how to systematically eliminate them and get as close to perfection as possible. In order for a company to achieve Six Sigma, it cannot produce more than 3.4 defects per million opportunities.

There are two Six Sigma processes: Six Sigma DMAIC and Six Sigma DMADV, each term derived from the major steps in the process. Six Sigma DMAIC is a process that defines, measures, analyzes, improves, and controls existing processes that fall below the Six Sigma specification. Six Sigma DMADV defines, measures, analyzes, designs, and verifies new processes or products that are trying to achieve Six Sigma quality. All Six Sigma processes are executed by Six Sigma Green Belts or Six Sigma Black Belts, which are then overseen by a Six Sigma Master Black Belts, terms created by Motorola.

Six Sigma proponents claim that its benefits include up to 50% process cost reduction, cycle-time improvement, less waste of materials, a better understanding of customer requirements, increased customer satisfaction, and more reliable products and services. It is acknowledged that Six Sigma can be costly to implement and can take several years before a company begins to see bottom-line results. Texas Instruments, Scientific-Atlantic, General Electric, and Allied Signal are a few of the companies that practice Six Sigma.

## 2: Global-8D:

Ina Bauer-Kurz, College of Textiles, North Carolina State University, Raleigh:

Global-8D is a problem-solving methodology for product and process improvement. It is structured into eight disciplines, emphasizing team synergy. The team as whole is better and smarter than the quality sum of the individuals. Each discipline of G8D is supported by a checklist of assessment questions, such as “what is wrong with what”, “what, when, where, how much” for D2, problem description. Throughout the problem solving process, achievements of each discipline are summarized and recorded in a G8D spreadsheet.

The 10 step problem solving process is more effective and more complete than 6-Sigma and the 6-panel process. It will take more time to apply the 10-step problem solving than any other method but for sure it is the most comprehensive method for problem solving manufacturing.

## CHAPTER ONE: MATERIALS AND METHODS

### *Step one: Emergency Action*

#### Emergency Response Action

The first step is the implementation of an Emergency Response Action (ERA) to protect customers from the problem while a team is established. Also at "step one", users review application criteria to make sure that 9 steps are justified.

A lot of time, people, and resources can be involved -and wasted- if using the process is not justified. The first step helps on focusing on the problem so that the resources can be used efficiently.

The application criteria helps to justify the use of the process. If the application criteria is not used to justify, it will end up unnecessarily solving every single problem with an intensive process.

At automotive industry the ultimate goal is to lead the industry in product excellence and customer satisfaction. This goal will require an Emergency Response Action (ERA) to protect customers from problems. An ERA is an important part of maintaining customer satisfaction and reaching the goals.



An Emergency Response Action (ERA) is any action taken to protect customers and affected parties from a symptom while the necessity of the next steps is being verified.

ERA may be as extensive as stopping all shipments or as minimal as doing nothing at all, depending on the nature of the problem, the cost factors, and the severity and extent of customer complaints.

An ERA can be difficult to prove with a measurement, because it is often based on common sense. For example, it's common sense to verify that customers will not experience a symptom any more if the manufacturer stops shipping products that are affected.

After selection, verification, and implementation of an ERA, the team must validate that it is working. Validation provides ongoing evidence that the ERA is doing what it was intended to do without introducing any new problems.

Pre-customer validation includes:

(1) Tests, (2) Inspections, (3) Observations, (4) Quality checks on products and processes, (5) Customer validation includes customer feedback, (6) Application

Criteria:

There are six criteria for initiating the process:

- (1) The symptom has been defined and quantified.
- (2) The customers experiencing the symptom and the affected parties have been identified.

(3) Quantifying measurements show that a performance gap (poorer performance than desired) exists and/or the priority (severity, urgency, growth) of the symptom warrants the process.

(4) The cause is unknown.

(5) Management is committed to fixing the problem at the root cause level and preventing recurrence.

(6) The 9-step problem-solving process distinguishes between problems and symptoms. The most important part of the application criteria is the symptom. Without a symptom, it is not known that a problem exists.

A symptom is a measurable event or effect that indicates the existence of one or more problems. The event or effect must be experienced by one or more customers.

A problem is a deviation from an expectation, or any unwanted effect where the cause is unknown. Symptoms are the manifestations of a problem

only symptoms that can be measured or quantified should be considered when initiating the 9-step process. If the symptom can not be measured, there is either not enough information or not a valid reason to conduct a process. Quantification may come from data that already exists, such as warranty repairs/costs or customer satisfaction surveys.

## Assessing Questions/Checklist

Assessing Questions helps the team determine if the steps of the 9-step process have been completed.

Assessing Questions are designed to:

- Keep the team and the Champion focused on tasks
- Provide a quality assurance check
- Aid in the organization of data through out the process
- Perform a short term check during the process
- Help identify the necessary resources and the timing of the recourses
- Serve as a check list guide for completing the process

Assessing Questions helps to insure that each step is completed and done well.

The questions ensure consistency in the application of the 9-step process.

However, for any given problem, not all questions may apply. In some cases it may be necessary to add questions when appropriate. It is important to make sure that the accessing questions are reviewed as each step in the process is completed. It is not necessary to memorize these questions; they are available in the reference section and are meant to be used by the team as each step in the process is completed.

Appropriately included in the Assessing Questions for each step are common tasks. Common tasks are maintenance tasks that should (when applicable) be performed during each step of the process.

Common tasks include:

- Documentation all changes
- Review measurables
- Update the 9-step testing report

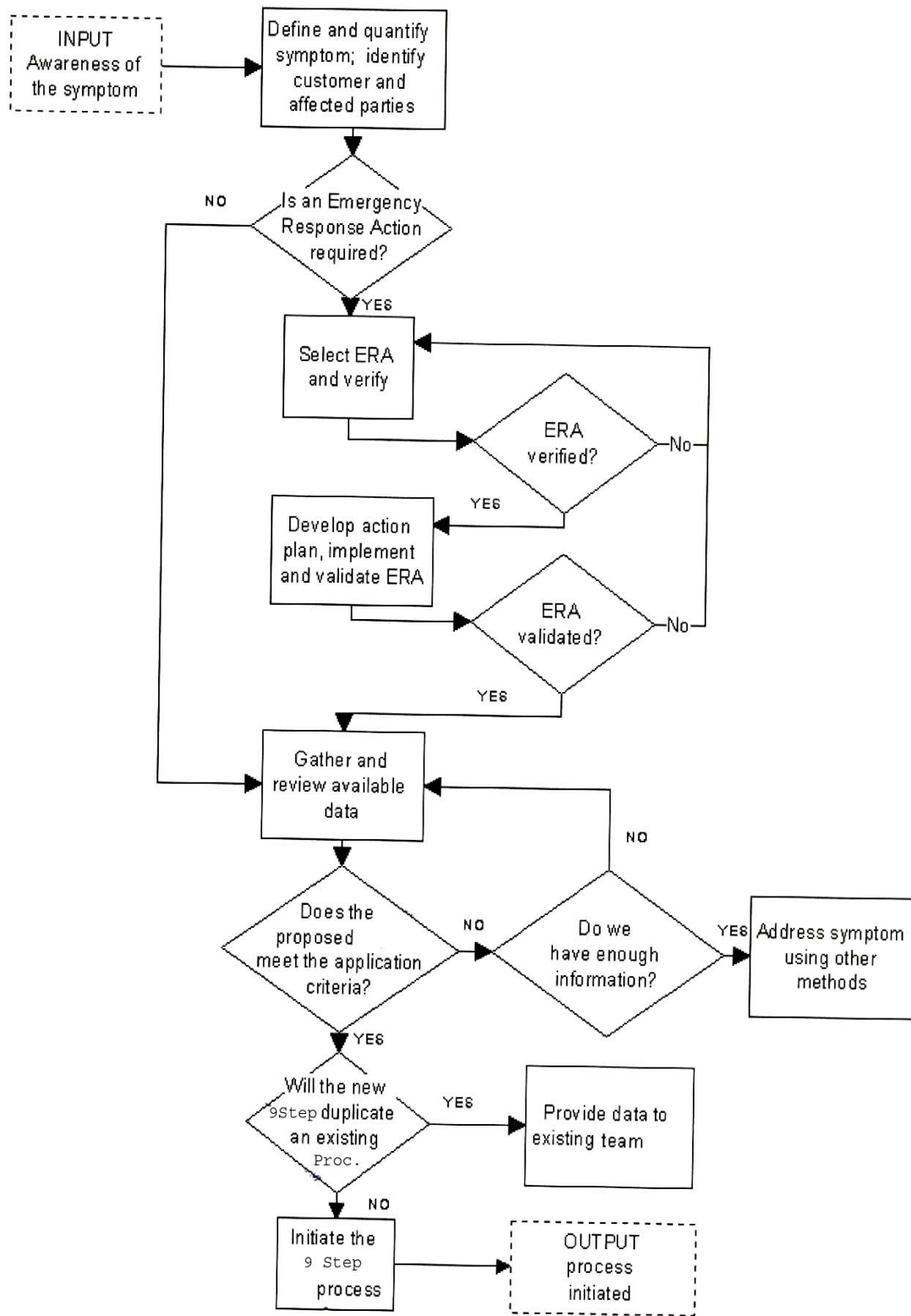


Figure 1: Prepare for 9step problem solving

### *Step two: Establish the team*

In order to solve the problem and proceed with 9 step, a team needs to be established. A small group of people with the process and/or product knowledge, allocated time, authority, and skill in the required technical disciplines to solve the problem and implement corrective actions need to be established. The group must have a designated champion and team leader. The group begins the team building process.

When determining team membership it is necessary to limit membership to between four and ten members. Fewer than four members will not produce enough innovation. Teams with more than ten members may experience interpersonal problems and may have trouble reaching an agreement.

The steps below need to be followed:

- Members need to be chosen with the right skills, knowledge, resources, authority, etc., to solve the problem at hand. The customer's viewpoint must be represented. The team members must also know why they've been selected to participate.
- Right mix of people with define qualifications need to be chosen. Not everyone should come from the same department and the same job functions. People with different experiences and talents will force teammates to look at the situation from a different perspective.
- At different times, different types of expertise or information are needed. The members should be allowed to rotate on and off the team as necessary.

Once a team has been selected, team members need to work as effectively as possible. This process depends upon the efforts of all team members to achieve the team's objectives. To do this, each team member performs a role.

Each role focuses on functions rather than individuals. This helps the team remain focused on the process and work efficiently instead of becoming sidetracked by personal differences. The roles on this team are interdependent. No one person can do it all by himself/herself.

#### The team

- The team should be as followed:

#### *Champion:*

The Champion is the person who has the authority to make (and implement) decisions regarding Short term Containment, Permanent Corrective, and Preventative Actions. The champion also supports the team's problem-solving efforts throughout the process.

This member also perform the following:

- Sets priorities,
- Assigns the team to complete the process
- Helps remove organizational barriers

#### *Team Leader:*

The Team Leader is the person responsible for leading team members through the process. This person has leadership and interpersonal skills and should perform the following tasks:

- Leads the team to complete each objective
- Acts as the team's business manager
- Works with the team to set objectives and tasks
- Asks for and summarizes members' opinions
- Develops agendas for meetings and team activities

*The Time Manager:*

The time manager will keep track of timing through out the process and also meetings.

This member should also perform the following tasks.

- Allocates time to each agenda item
- Monitors meeting progress against the agenda
- Keeps time for the team
- Proposes agenda time adjustments

*The Scribe:*

The Scribe records the Leader's summary

This member should also perform the following tasks:

- Restates and records team decisions during meetings
- Makes team decisions visible



- Sometimes the role of scribe is combined with the role of Recorder.

#### *The Recorder:*

The Recorder is a team member who generates, holds, and publishes team reports, meeting minutes, action plans, etc.

Controls documents for the team

Tends to be an administrative support person for the team

Takes responsibility for creating and distributing meeting minutes and reports in a timely fashion

#### *The Facilitator*

The Facilitator's primary task is to help the team with interpersonal issues such as resolving conflict, arriving at consensus (when appropriate), handling negative group behaviors, etc.

Works with the team to resolve conflicts

Ensures that all team members have the opportunity to contribute

Focuses on team maintenance

Acts as a team builder

#### *The Team Member*

Team Members are those who are selected to participate on the team because of their experience and knowledge. They are subject matter experts who

may not perform another role on the team. Team Members might change during the process.

- Roles are not people. Roles are functions that people fulfill. However, certain people are better at certain roles than others. For example, someone who is not assertive may make a bad time manager or leader. It is necessary to match skills to roles so that each role will be handled in the most effective manner.
- Members often hold roles for the duration of the meeting or longer.
- Roles can be changed in the middle of a meeting. However, when team members exchange roles in the middle of a meeting, confusion can result.
- Mid-meeting role changes need not be disruptive if all team members are aware of the change.
- Some roles can be shared. For example, Facilitator and Time Manager, Recorder and Scribe. Leadership and facilitation roles should not be shared.
- Facilitation is essential throughout the discussion. This means that one person is not participating directly in the problem-solving task. When all team members have acquired the skill of facilitation, the role should be adopted by the person who potentially has the least amount of input.
- The Champion is a role in the process; however, the Champion is not considered to be a team member.

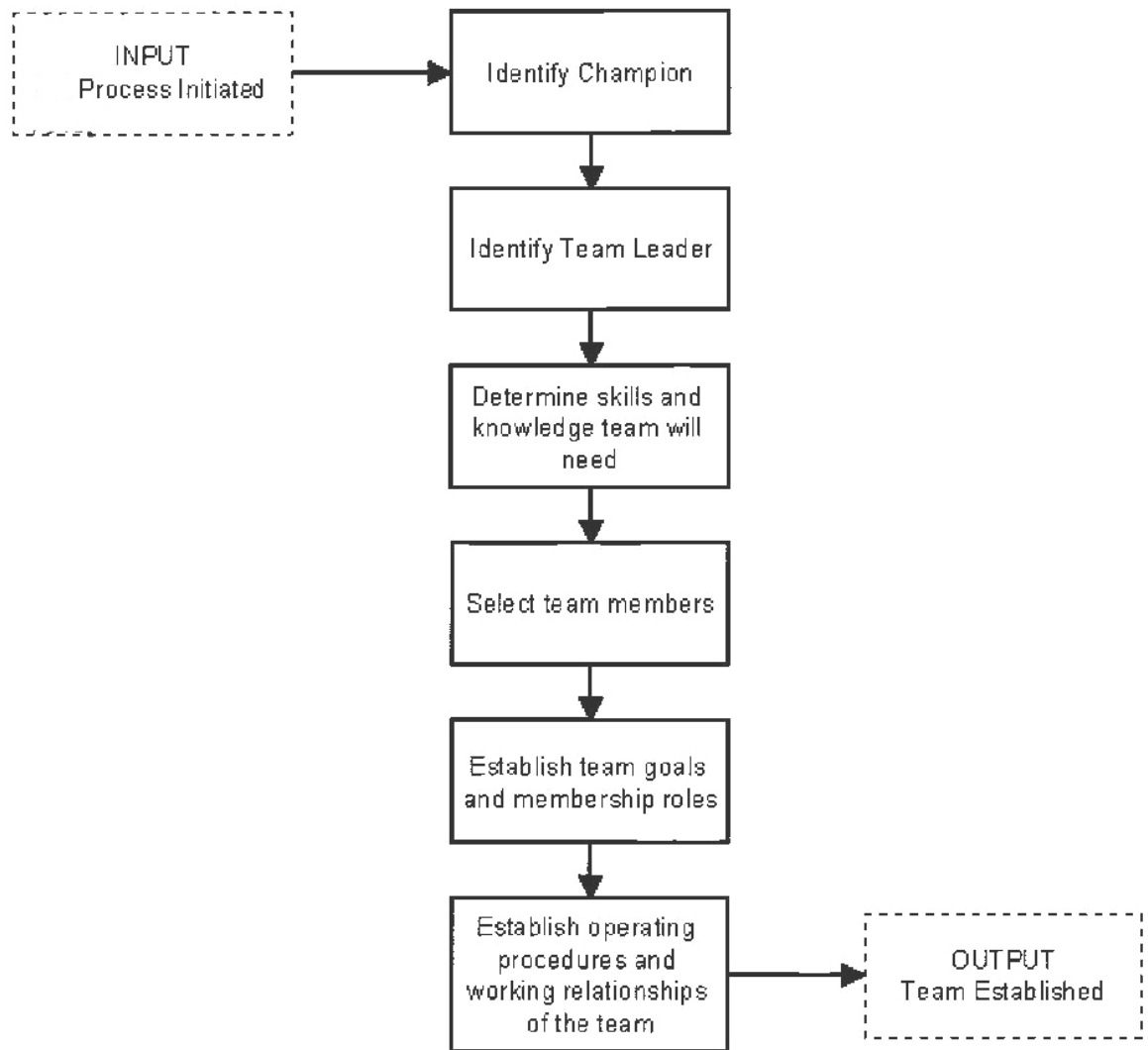


Figure 2: Establish a team

### *Step three: Establish the problem*

Develop a Problem Statement:

#### What Is Wrong with What?

To identify the object and the defect of a problem, The team needs to ask: "What is wrong with what?"

"What is wrong" is the defect. A defect is an unwanted characteristic found in a product or process.

"With what" is the object? The object is the specific product or process that exhibits the defect.

#### Repeated Whys

Once the object and defect are established, the next step is to refine them.

Refining helps the team:

- focus its efforts on a single problem with a single root cause
- get as near as possible to the root cause using existing data
- check to see if the cause of the problem is unknown

### Separate Symptoms into Multiple Problem Statements

In industry, as in real life, problems come in multiples. Unfortunately, problem solving works best on one problem at a time. Complex, multiple, or vague problems should be separated, prioritized, and dealt with one at a time. The goal is to translate the customer's symptom into a problem statement.

### Develop a Problem Description

Next, develop a problem description. A problem description defines the boundaries of the problem in terms of what the problem is and what it is not, but could be. A problem statement gives the basic facts, but a problem description gives the details necessary to find the root cause.

Why a problem statement should be developed? Detectives limit their searches by excluding non-possibilities. Developing a problem description helps the team do the same thing—narrow the search.

To develop a problem description, the problem should be related to the four dimensions—what, where, when, and how big:

- What the problem is and what it is not, but could be
- Where the problem is and where it is not, but could be
- When the problem occurs and when it does not, but could occur
- How big the problem is and how big it is not, but how big it could be

### Using an Is/Is Not Worksheet

The *Is* information on an *Is/Is Not Worksheet* defines the problem based on the information at hand. The *Is Not* data helps narrow the search. The *Is/Is Not* data:

- describes the scope or extent of the defect
- includes just the facts
- is part of the observation phase of problem solving

When *Is Not* data is developed, the below steps should be followed:

- include only facts, not "jumping to conclusions"
- look for "close cousins"—objects similar in shape, composition, form, function, etc.
- create at least one *Is Not* for each *Is*
- include as much information as possible from the information at hand

*Is/Is Not* data represents unbiased facts about the problem. It is necessary to use the "Get Information" column to keep track of information that is needed but has not yet been collected.

To solve problems effectively, the problem need to be define accurately and thoroughly.

Once the problem is define, the team can work on finding the root cause and take action to solve the problem. However, some time is needed to determine the root cause.

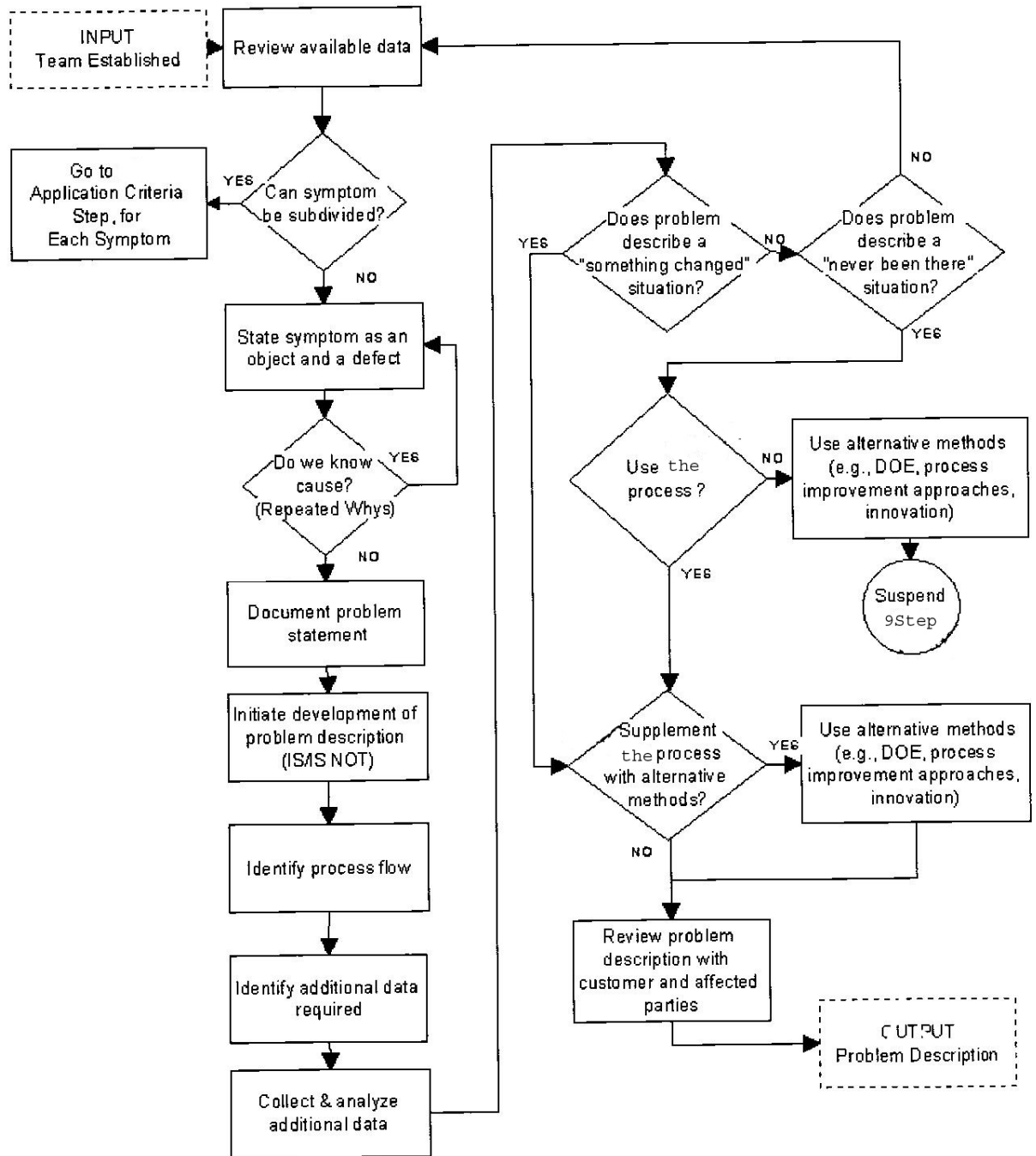


Figure 3: Establish the problem

#### *Step four: Develop a Short term Containment Action (SCA)*

This step provides the opportunity to develop short term containment Actions until Permanent Corrective Actions are implemented. The SCAs isolate the effects of the problem from any internal/external customer.

#### Why Develop a Short term Containment Action (SCA)?

A short term containment action (SCA) helps maintain and build customer satisfaction in problem situations. When a SCA is developed, below steps should be followed:

- "Buy time" so that the team can find the root cause of the problem
- Protect the customer from the effects of the problem
- Contain the problem from a cost, quality, and timing perspective

A SCA isolates the effects of the problem from both internal and external customers until a permanent corrective action can be implemented.

A SCA protects customers until the root cause is known. If the root cause is known, or if the ERA is robust enough to continue protecting customers, SCA may not be necessary.

The SCA works against the problem, not against the root cause. Because it is separate from the root cause, other team members can work on the next step (Define/Verify Root Cause) while an SCA is verified and validated.



There are four steps to developing an SCA:

- select the SCA
- verify the SCA.
- implement the SCA.
- validate the SCA.

A Short term Containment Action (SCA) is any action that prevents customers from experiencing the symptoms of one or more problems. A SCA:

- attacks the symptom of the problem
- is verified for effectiveness before it is implemented
- is monitored while it is in use
- is documented
- is replaced by a Permanent Corrective Action
- Adds cost to the process/operations

### Select a SCA

Because a SCA adds cost, the situation needs to be considered carefully before selecting an SCA. the following questions need to be asked to determine if an SCA is necessary:

- Is an SCA necessary based on step2 data?
- Can the ERA be improved?
- Do we know, with certainty, what the root cause is so that an

immediate, permanent fix can be implemented?

- Do we need to buy time so that we can determine the root cause of this problem?

If an SCA is required, the "best" SCA for our situation need to be selected. To select an SCA:

- Establish selection criteria. For example, the SCA must protect the customer from the problem and not introduce any more problems. Criteria might also include a time frame, a performance level, maximum costs, minimum negative publicity, etc.
- Analyze benefits of implementing the SCA
- Analyze risks of implementing the SCA
- Choose the SCA with the best balance of benefits and risks

An SCA is kept in place until a verified permanent corrective action can be implemented. In some cases, the SCA may be the same as or similar to the emergency response. However, an ERA is implemented with minimal supporting data. An SCA provides more opportunity for investigation.

Any SCA that is implemented must protect the customer from the problem without introducing any new problems. In addition, a single SCA may not be enough. More than one SCA may be required to fully protect the customer

### Verify a SCA

A SCA can be any action that protects the customer from the problem. However, before SCA is implemented, it is necessary to verify that the SCA will work.

When the SCA is verified, the team should:

- prove, before implementation, that it will prevent the customer from experiencing the problem
- provide a before-and-after comparison
- prove that the SCA will not introduce any new problems

Methods of verification may include:

- tests — For example, an engine test would verify that a change to an engine component has achieved the desired performance level.
- demonstrations — For example, a visual test would determine if a change in a component's handling system eliminates damage without creating a new problem.
- comparisons between the SCA and similar proven actions — For example, if using a new oil in department A has improved part finish while increasing tool life, introducing the oil to another department could be compared to this situation.
- reviews of pre-release design documents such as policies, procedures, drawings, and specifications to evaluate if a SCA has accomplished what was intended without introducing a new problem.

Trial runs need to be conducted wherever possible. However, in some situations, the verification—like an ERA—may simply be a matter of common sense. For

example, if a SCA involves stopping the shipment of all products, It needs to be sure that customers will stop experiencing the problem. Yet, this might create additional problems for the customers and the manufacturer. For example, if the customers do not get any of the products, they might be forced to go to another vendor. The team must consider all of the trade-offs connected to the SCA.

An important part of implementing a SCA is planning how to implement the action. To implement an SCA it is necessary to:

- follow the management cycle
- create an action plan



Figure 4: Management cycle

## Implement a SCA

The steps to the management cycle are:

- Plan — determine which actions must be accomplished to reach our objectives by the target completion date.
- Implement the plan.
- Act — evaluate the results.

As part of the management cycle planning phase, an action plan should be created. An action plan describes:

- What actions are necessary to reach an objective
- Who is responsible for completing specific actions
- When the actions must be completed

### The Action Plan

An action plan helps to build a case for implementing the chosen SCA and shows the champion that all the necessary work are done and verified. A SCA should not be implemented without the champion's knowledge or involvement.

### Validate a SCA

After the SCA is implemented, it needs to be validated. Validation is the ongoing evidence that the SCA is doing what it was intended to do without introducing new problems. Validation should always follow successful verification.

- Pre-customer validation — ongoing evidence, before exposure to the customer and after successful verification, that the action is still doing what was intended. Pre-customer validation may include tests, inspections, observations, and other quality checks.
- Customer validation — Ongoing evidence from the customer that the SCA is working. Confirmation is obtained by monitoring the same indicator that initially demonstrated the symptom..

## Key Points

The purpose of this step is to define, verify, implement, and validate a short term containment action (SCA). The SCA isolates any customers from the effects of the problem until a permanent corrective action can be implemented.

Implementing a SCA buys the team time to solve the problem at its root cause.

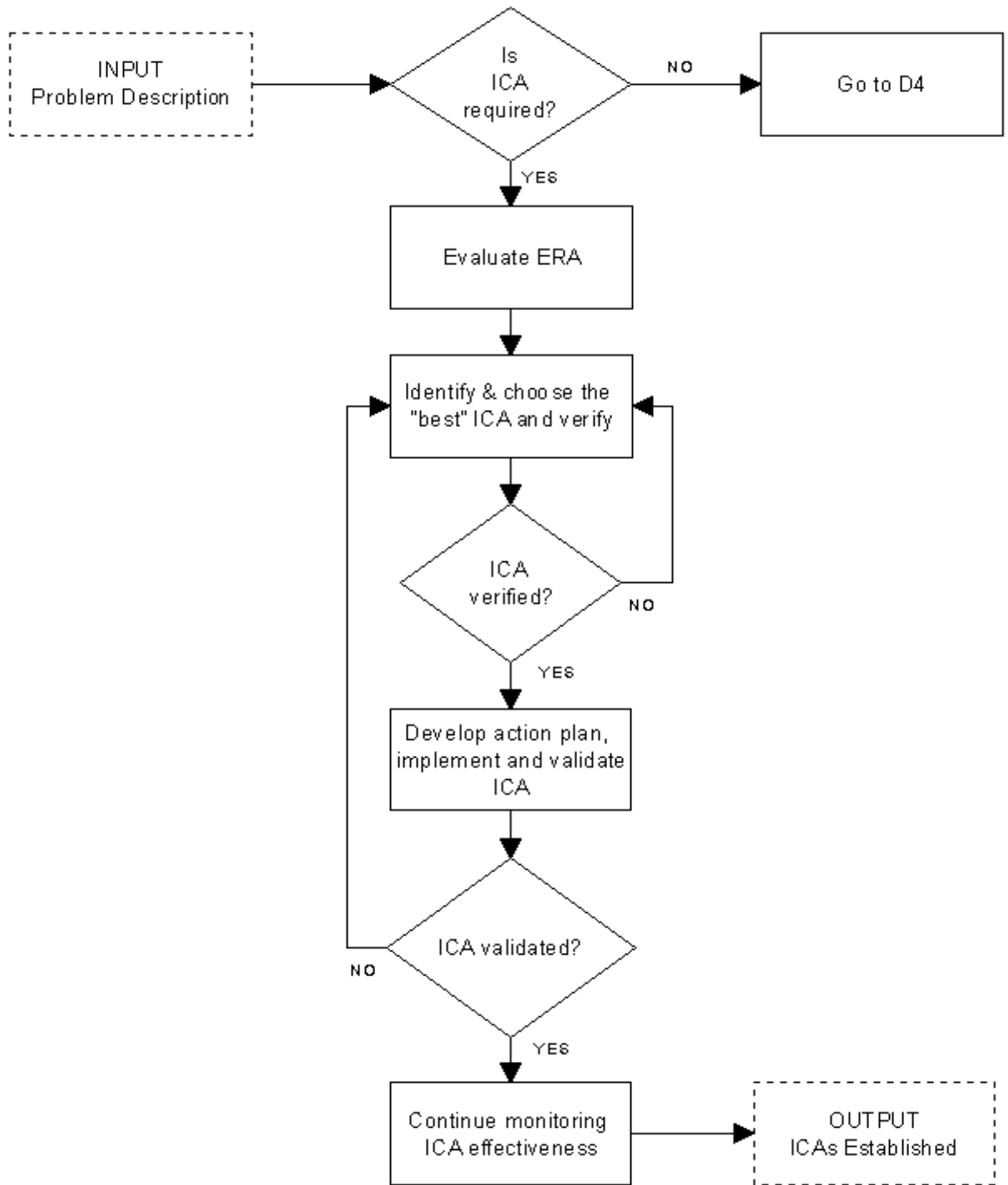


Figure 5: Develop a Short term or an Interim Containment Action (SCA):



### *Step five: Define and Verify the Root Cause and Escape Point*

This step provides the opportunity to test each root cause theory against the problem description by isolating and verifying the root cause. Also at this step, users isolate and verify the place in the process where the effect of the root cause could have been detected and contained.

#### Why Define and Verify the Root Cause?

Finding the root cause is the most important part of any problem-solving effort. When the root cause is identified, problem can be solved at its most basic level.

Any problem-solving effort that doesn't focus on the root cause merely places a Band-Aid on the situation. A Band-aid can mask the information, the real root cause has to be identified. When the root cause is identified, problem has to be eliminated entirely so that it never occurs again.

Although identifying the root cause may seem time-consuming, it is actually more time-efficient in the long run because:

- We don't have to come up with one "quick fix" after another
- We don't waste time and effort on damage control
- We don't have to constantly rebuild customer satisfaction
- We solve the problem once and for all

Other employees and teams can learn from the team's efforts and prevent problems before they occur. The work at Step 4 is really the heart of the problem-solving process.

### What Is the Root Cause?

- Possible cause — any cause, frequently identified on a Cause and Effect Diagram, that describes how an effect may occur.
- Most likely cause — a theory, based on available data, that best explains the problem description.
- Root cause — a verified cause that accounts for the problem; verified passively and actively by making the problem come and go.

The process used in Step 4 helps us slowly narrow the search for a verifiable root cause.

### Identify the Root Cause

How can the most likely cause be identified?

To identify the most likely cause, below steps should be followed:

Step 1: Review the problem description (*Is/Is Not* Analysis)

Step 2: Complete a comparative analysis for change-induced situations (identify differences and changes)

Step 3: Develop root cause theories

Step 4: Test theories against the problem description

Until the most likely cause is verified, the root cause is not verified.

### The Problem Solving Worksheet

The Problem Solving Worksheet is the primary tool used to assist in identifying the root cause. This worksheet will help to focus the efforts and manage and interpret the gathered information. There are four pages to the Problem Solving Worksheet:

Page 1: Problem Description

Page 2: Comparative Analysis

Page 3: Root Cause Theories

Page 4: Trial Run of Root Cause Theories

### Types of Problem Situations

There are two types of problem situations:

- Change-induced situations are those situations in which a product or process deviates from the expected level of performance. The change in performance may happen gradually or abruptly and may be intermittent, unpredictable, or unstable.
- Never-been-there situations are those situations in which a new event has occurred or a desired or intended level of performance has not been reached

All problems fall into one of these two categories. How the root cause is identified may depend on the type of problem situation. A comparative analysis may not be done for a never-been-there situation.

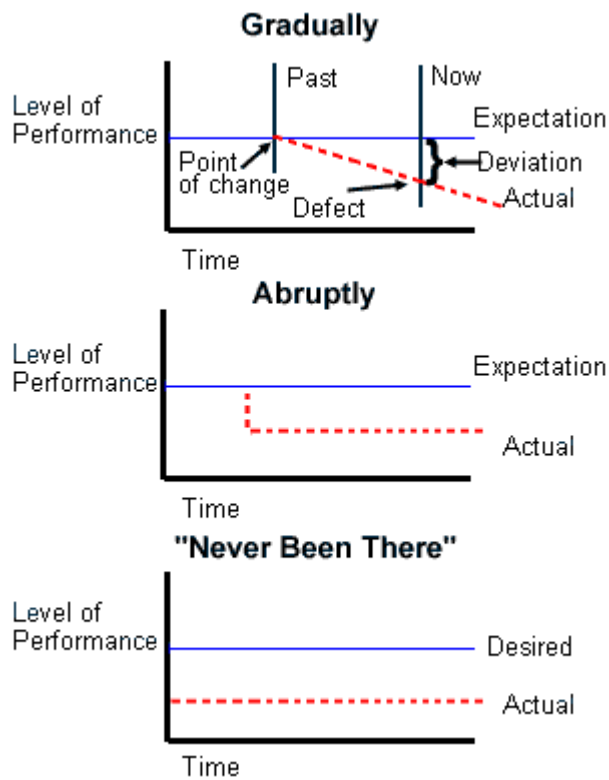


Figure 6: Level of performance/Time

### Step 1: Review the Problem Description

To identify the root cause, first the problem description should be reviewed (the *Is/Is Not* Worksheet).

- The problem description describes problems in terms of what, where, when, and how big.
- All answers to the *Is/Is Not* questions must be facts (observations).
- All contrasting information in the *Is/Is Not* columns should be similar in category, shape, form, function, and composition.
- All information must be gathered before identifying the root cause can begin.

All of the above factors need to be true before moving to the next step.

### Step 2: Complete a Comparative Analysis

Once the problem description is reviewed, a comparative analysis should begin. Just as "narrowing the search" when completing the problem description, a comparative analysis helps identify relevant changes in a change-induced situation. Then the number of possibilities can be reduced to identify the root cause.

To complete a comparative analysis, each *Is* should be compare with its corresponding or contrasting *Is Not*.

- "What is unique, peculiar, different, distinctive, or unusual about the *Is*?" should be asked.

- Features such as people, methods, materials, machines, and the environment should be considered.
- List all facts without prejudice as to the possible cause.

List all of the differences in the Differences column of the Comparative

Analysis section of the Problem Solving Worksheet. The differences:

- Are facts
- Are unique to the *Is*
- Have not already been stated in the *Is* column

Next, It is necessary to consider each difference listed in the Differences column, and look for changes. Also below steps should be followed:

- "What has changed in, on, around, or about this difference?" should be asked. For example, if the difference is an electric motor, "What about the electric motor has changed?" need to be asked.
- Each difference may not have a corresponding change.
- The changes in the changes column of the Problem Solving worksheet have to be listed.
- Each change that occurred must be looked at. Some changes may be eliminated if they occurred after the problem started.

- Categories of people, machines, materials, methods, measurements, or the environment must be considered.

If the problem is change-induced, the root cause must be the result of a change relative to one or more of the identified changes.

It is important to remember that this is still the "observations" phase of the process. Any information developed in a comparative analysis must be facts, not opinions, and must be true only for the information. Any fact should not be ruled out in case they are valid answers. If it is a fact and it answers the question, then it should be written down.

### Step 3: Develop Root Cause Theories

Now that possible root causes have been narrowed down, Theories about how the problem occurred must be developed. Theories are statements of ways that the changes may have created the problem.

To develop theories the below guidelines should be followed:

- Use brainstorming techniques to generate ideas.
- Ask: "How could this change have caused the problem?" Continue to ask the question until all possible theories are developed.
- List at least one theory for each change.
- List each theory individually on the worksheet.

- List every possibility, no matter how strange or unlikely. Don't reject or qualify any theory.
- Start with the simplest single change/single variable theory first. Then work up to more complex theories.
- Be specific. Avoid generalities such as "poor quality" or "doesn't work."

#### Step 4: Test the Theories

At Step 4, the team applies critical thinking to rule out theories and settle on a most likely cause. To apply critical trial runs:

- Critically evaluate a theory against sets of *Is/Is Not* data
- Test the likelihood of the theory
- Test the plausibility—not the remote possibility—of each theory

The trial run is an attempt to test if each theory can explain what did happen to cause the problem. It is not an explanation of what might happen in the future.



To test a theory, below steps must be followed:

- Ask: "Does this theory explain both the *Is* and *Is Not* data? If so, how?"
- Test the theory against each individual set of *Is/Is Not* data.
- If the theory fully explains why this problem happens in the *Is* but never happens in the *Is Not*, place a plus sign (+) in the appropriate column of the Trial Run section of the Problem Solving Worksheet.
- If the theory cannot explain why the problem happens in the *Is* and/or never happens in the *Is Not*, place a minus sign (-) in the appropriate column and note the reason it doesn't explain the theory.
- If a theory could explain the problem, not enough information is provided to fully explain why it happens in the *Is* and/or never happens in the *Is Not*, place a question mark in the appropriate box on the worksheet and note why the theory is uncertain. More data might need to be gathered to prove or disprove these theories.
- Test simple (single change) theories first. Test highly complex or interactive theories last.

The root cause must explain all known data. Any theory with a minus sign, whether for *Is* or *Is Not* data, does not explain all known data. However, multiple theories with a minus sign can collectively account for all of the problem description and should be considered as complex root causes.

Any theories that pass the trial run are most likely causes. If only one theory passes the trial run with just plus signs and question marks, then verify this theory as the root cause.

However, more than one theory may pass the trial run. In those cases (and when practical and feasible), collect and analyze any missing data for uncertain theories and reexamine information to resolve uncertainties.

If additional information reveals that a theory cannot fully explain why the problem happens in the *Is* but never happens in the *Is Not*, eliminate it from consideration.

If it is not feasible to gather and evaluate additional information, need to verify each remaining theory. Verification has to start with the theory with the most plus signs. The theory that best explains the *Is/Is Not* data is the most likely cause.

Once the most likely cause(s) have been determined, verify that it actually causes the problem. Verification is done passively and actively:

Passive verification is done by observation.

- Look for the presence of the root cause without changing anything.
- If the presence of the root cause can not be proven, then this identified cause is probably not the root cause

Active verification is done by manipulating the root cause variable.

- Implement and remove the root cause variable to make the problem "come and go."

- Both "coming" and "going" are essential tests to confirm the root cause.  
There can be more than one verified root cause.

### Determine and Verify the Escape Point

After the root cause has been determined and verified, it is necessary to determine the escape point of the problem. An escape point is the point closest to the root cause at which the problem could have been detected but was not.

A control system is a system deployed to monitor the product/process and ensure compliance to quality requirements. A control system consists of responsibilities, procedures, and resources.

A control point is a location within the control system at which the product/process is checked for compliance to the quality standards. A product or process may have more than one control point within the system.

When the escape point is identified, work needs to be done to improve or establish a system to ensure that if problems occur, they will not go undetected.

To understand how the problem escaped to the customer and identify the escape point below steps need to be followed:

- Review the process flow focusing on the location in the process where the root cause occurred.

- Determine if a control system exists to detect the problem.

If none exists, the development of a new control system must be considered in the problem solution.

If a control system currently exists:

- Identify the control point closest to the root cause.
- Determine if the control point is capable of detecting the problem.

If the control system is not capable, the development of an improved system must be

part of the problem solution.

If the control point is capable of detecting the problem, then the control point is the verified escape point.

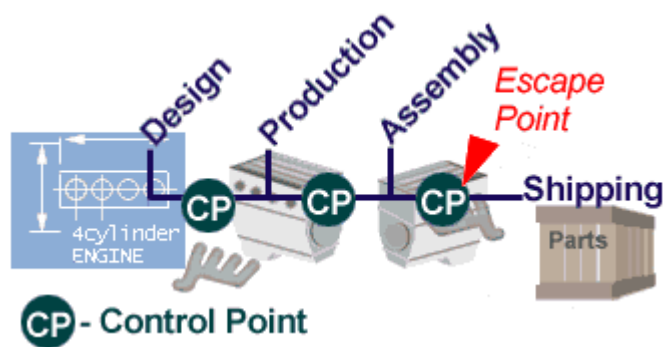


Figure 7: Control Point

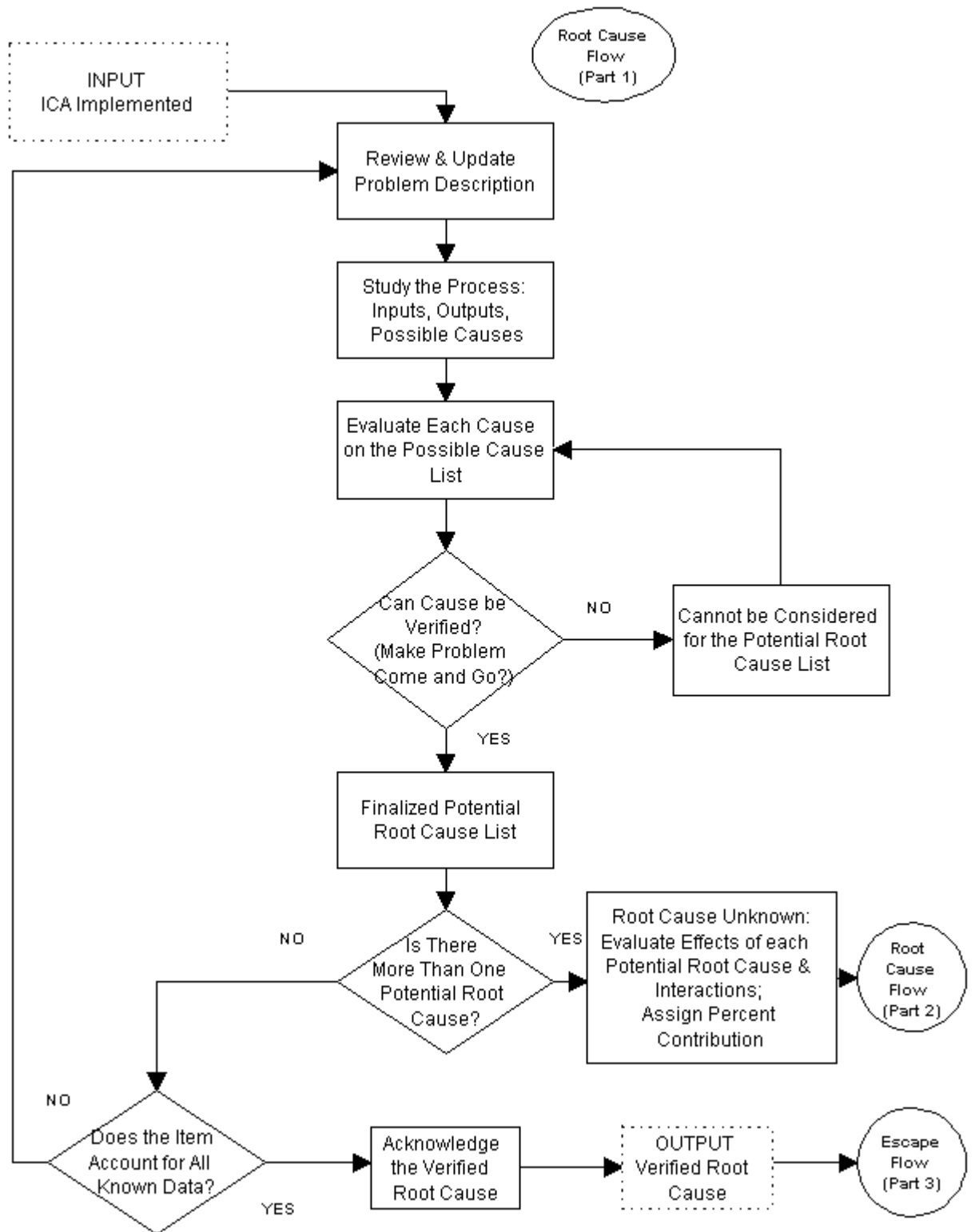


Figure 8: Define and Verify the Root Cause and Escape Point

*Step six: Choose and Verify a Permanent Corrective Action (PCA).*

This step provides the opportunity to select the best Permanent Corrective Actions to remove the root cause. Also, users select the best PCAs to contain the effect of the root cause and verify that both decisions will be successful when implemented without causing undesirable effects.

Why Choose and Verify a Permanent Corrective Action?

The main intention is to solve the problem. At the end, the team will decide on the best Permanent Corrective Action for both the root cause and escape point.

When the decision-making process is used to choose a PCA, reason and good judgment are employed to weigh the options and pick the most effective and efficient solution. In short, it needs to be assured that the problem will not occur again and that no new problems come up.

In this step focus needs to be on decision-making and verification. By focusing on these two steps, the team can:

- Make the best decisions based on benefits and risks
- Verify that the chosen solution will work

The work done here helps prevent a rushed implementation and sets the stage for validating the PCA. Validation is covered in the next step.

## What Is a Permanent Corrective Action?

Although ERAs and SCAs protect customers from the effects of a problem, they generally do not eliminate the root cause. Instead, they may mask the symptoms while the problem continues. A Permanent Corrective Action (PCA), on the other hand, is the best action or actions (there may be more than one) that eliminate the root cause of a problem.

For example: We heard complain from one of the customers that his car started to make lots of noise.

To protect customers from the problem, the vehicle was tested and a small hole was found in the muffler.

At this point the root cause is eliminated by replacing the muffler. This is a PCA because it removed the problem at the root cause.

### Choose a PCA

The decision-making process helps teams choose the best PCA the first time. This involves getting the team to make a good decision when faced with multiple options. Often, when several options are available, the best choice is not always clear.

Any PCA chosen should:

- Fix the problem at the root cause level
- Generate no additional problems

### Be verified to work

The decision-making process is a technique for prioritizing options. It requires consensus from the team. All team members should come to an agreement on a selected action through discussion and learning rather than through compromise. The members support the decision that benefits the team as a whole.

How well the decision-making process works depends on the experience of the decision-makers and the criteria that is applied.



## The Decision-Making Process

The decision-making process has seven steps:

Step 1: Describe the end result

Step 2: List decision criteria (givens and wants)

Step 3: Determine the relative importance of wants

Step 4: Identify choices

Step 5: Compare choices to decision criteria

Step 6: Analyze risks

Step 7: Make the best choice

The Decision-Making Worksheet can help to work through the decision-making process. Each section corresponds to a step in the process. This worksheet allows to document decisions and variables and keep the process on track.

### Step 1: Describe the End Result

Every decision has a purpose or an objective. Every option considered should keep this end result in mind. The end result is a brief statement about the desired outcome of the decision—how things will work when the root cause of the problem is removed. The team needs to identify the end result to:

- Define the scope of the decision
- Provide a focus for our thinking

Describing the end result helps to ensure that each member of the team is working toward the same goal and is considering the same variables. Any option that does not support the end result is unnecessary and should not be considered.

Some end results might be stated as follows:

- Buy a computer
- Choose an administrative assistant

### Step 2: List Decision Criteria

There are two types of decision criteria—givens and wants.

Givens:

- Are objectively measurable
- Are non-negotiable
- Are realistic features of the decision
- Often involve money, deadlines, company procedures, or legislation

Givens are the minimum criteria for making a choice. Givens will be used to filter out choices. Givens determine which choices will be considered.

Wants:

- Are measurable (objectively and subjectively)
- Are the desirable (rather than essential) features of the decision
- Allow us to determine which of the remaining choices are preferable

- Generate the criteria that are required for an ideal choice in terms of resources that can be used

After all choices that do not meet the givens are removed from the list, wants will determine which choice will be chosen. The Champion must agree with all PCA criteria.

### Step 3: Determine the Relative Importance of Wants

Each want has a relative importance when considered against the end result. The relative importance allows each available option to be evaluated in a way that reflects its merit. Some wants are more desirable than others. To determine the relative importance of each want:

- Assign the most important want a rating of 10 on a scale of 1 to 10 (with 10 being the highest)
- Compare each remaining want to the most important want. If another want is only half as valued, rate it a 5. If another want is almost as valuable, rate it an 8 or 9.

To make the decision-making process more effective in discriminating between good alternatives, the most desirable choice should always be rated a 10. Only one choice should be rated a 10.

Every member of the team may have different opinions about the relative value of wants. The urge to average the opinions has to be resisted.

#### Step 4: Identify Choices

Now that decision criteria is established, some choices need to be made. It is necessary to generate a list of alternatives that would solve the problem at the root cause. Some choices might already be provided to the team (ie team supervisor). The team, based on our own experiences, might identify other choices. Identifying choices might take several meetings, especially if the team needs to gather data.

#### Step 5: Compare Choices to Decision Criteria

Comparing choices and decision criteria enables us to evaluate how well each choice meets the criteria. It allows narrowing down options so the most desirable choice can be made. To compare choices to decision criteria the following steps should be followed:

- Compare each choice against each given. If the choice meets a given criteria, mark it "yes." If any choice does not satisfy the given, mark it "no" and eliminate it from further consideration.
- Next, compare or apply each want to the remaining choices. Rate each choice on a 1 to 10 scale (10 is the highest rating) as to how well the choice meets that want. Assign a 10 to the choice that best satisfies the want criteria. The best choice must be a "10."

This is the "how good" value of the choice. Rate other choices relative to the 10. For example, if we want a car with a lot of trunk space and our choices have 6, 8, or 10 cubic feet, we should rate the car with 10 cubic feet a 10, and rate the others lower.

- Multiply each choice's "how good" value with the importance value of each want.
- Total the scores for each choice. The score with the highest total is the choice that best satisfies the decision criteria and offers the most benefit.

The best decision will be made when all the risks are analyzed.

#### Step 6: Analyze Risks

Before a PCA is chosen, the risks involved with each choice need to be assessed. Risks are any features, characteristics, or extenuating circumstances associated with a choice that could result in a problem. Any choice carries associated risks. Sometimes the choices with the greatest benefits also have the greatest risks.

A risk has two elements to consider:

- How serious is the risk to the decision?
- How probable is it that the risk will happen?

To analyze risks below steps should be followed:

- Ask: "What things could happen (that haven't been considered yet) that might affect our success?"

- Next, ask: "What could jeopardize a successful implementation?"
- Consider the risks of failing to meet a given criteria. Also consider the risks of failing to meet a want.
- Consider problems that could develop with people, facilities, equipment, money, time, quality, ideas, policies, etc. (no matter how improbable).
- List each problem separately in the appropriate spot on the worksheets.
- Investigate one listed risk at a time. Consider how probable and serious each risk is.
- Estimate how likely each problem is to happen. Rate each problem on a 1 to 10 scale, with 10 being "definitely will happen," and 1 being "highly unlikely to happen." This is the probability score.
- Estimate how serious each problem would be if it did happen. Again rate it on a 1 to 10 scale, with 10 being "extremely critical" and 1 being "of little consequence." This is the severity score.
- Multiply the probability and severity score to get an overall risk rating. The closer to 100 the risk scores, the greater the chance that the risk will create other problems.
- This process should be continued for each risk that is identified for all top choices.

Once the risks are analyzed for the best choice, three possible courses of action should be taken:

- Reject the choice if the risks are too high. Look for the next best choice with lower risk.
- Commit to the choice anyway and work to prevent the risk from occurring.
- Put the decision on hold and further investigate the risks with input from a subject matter expert.

Again, determining risks can be highly subjective. Some people are more comfortable with higher levels of risk than others. Try to reach consensus with our team members.

#### Step 7: Make the Best Choice

Although many people would like to make decision making a foolproof process or an exact science, it is impossible to do so. All teammates may have different comfort levels with taking risks, so the team may feel differently about which choices are more or less acceptable.

A balanced choice must be based on all the information available to make sure it's the best choice possible for the situation. Often, the best choice might not be the first or most obvious choice.

### Verify a PCA (Test for Feasibility)

Now the best PCA has been identified for the problem using a process that minimizes subjective responses and builds consensus. But PCA's implementation, it still needs to be verified that it will work.

The PCA can be verified in the following ways:

- Conduct tests and demonstrations, such as off-line production runs
- Compare the new action to similar proven actions
- Review new design documents before their release



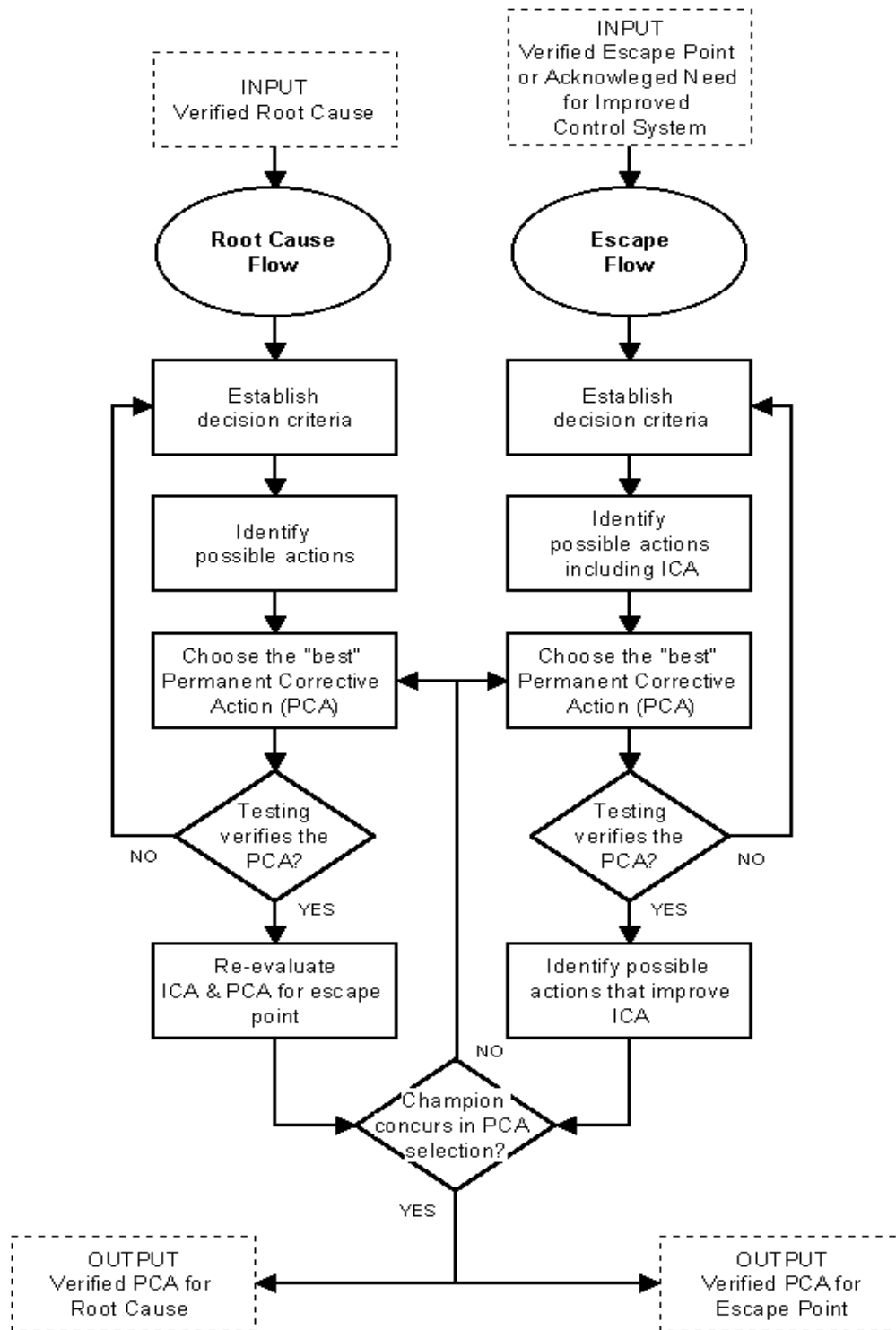


Figure 9: Choose and Verify a Permanent Corrective Action (PCA) for the Root

Cause and Escape Point

*Step Seven: Implement/Validate PCA (Permanent corrective action),*

This step provides the opportunity to implement selected Permanent Corrective Actions and in doing so remove the SCAs. Also, users Validate the actions and monitor the long-term results.

Why Implement and Validate a PCA?

In this step, the PCA will be implemented to eliminate the root cause of the problem. Validation makes sure that the PCA works as intended after implementation.

Planning is an important part of implementation and validation. When it is planned effectively, implementation will go smoothly because:

- No one is caught by surprise by any detail or unexpected event.
- Problems are prevented before they occur.

As a result, effective implementation provides the following benefits:

- No new planning problems develop.
- Customers will no longer experience any part of the problem.
- Team will have peace of mind.

Now it needs to be identified that every action that must take place for the PCA to be smoothly implemented. There are two phases to implementing a PCA:

planning and problem prevention.

### Plan the Implementation

In Step 3, the management cycle and created an action plan for implementing an SCA was learned. At step 6, the necessary steps to implement and validate the PCA will be planned. Team can base the plan on each phase of the management cycle.

The steps in implementation planning are:

- State our objective.
- Identify the standards and conditions to be met.
- Identify the key steps.

The focus can be on decision criteria by stating our team's objective, standards, and conditions.

Key steps are the most important actions in our implementation. Any problems or delays in completing a key step will affect the completion of all other steps. Key steps:

Are new, Have tight deadlines, Are complex, Have an impact on other steps

The experience should be used to identify key implementation steps. In the dinner example, our key steps would probably include gathering ingredients, reading the recipe, preparing cookware, and preparing ingredients.

### Prevent Problems

An important part of any PCA implementation is problem prevention. To prevent problems, team must systematically review each step in our implementation plan and ask:

- What could cause the step to go wrong?
- What can be done to prevent this from causing a problem?
- What should be done if a problem occurs anyway?
- Who initiates contingency actions, and what "cues" should let them know when to proceed

The first three steps in implementation focus on planning. Steps 4-9 focus on problem prevention, and step 10 revisits the planning stage. These steps are:

1. Rate the importance of key steps
2. Identify barriers
3. Identify prevention actions
4. Identify protection actions (contingency plans)
5. Develop cues for protection actions

6. Determine who initiates protection actions
7. Communicate the plan to everyone (revisit planning)

There's one final step in the process, in which we revisit the planning stage: communicate the plan to everyone involved.

The Problem Prevention Worksheet help planning and documenting the PCA implementation.

#### Problem Prevention Worksheet

The Problem Prevention Worksheet helps us plan and document our PCA implementation

**PROBLEM PREVENTION WORKSHEET 2 of 2**

**PROBLEM PREVENTION WORKSHEET 1 of 2**

**Objective of the Plan:**  
(Include due date)

KEY STEPS	PRIORITY			POSSIBLE BARRIERS/ CAUSES OF TROUBLE
	P	S	PxS	
Use your experience to identify steps of your plan that are complex, have tight deadlines, are high impact, are new, etc.	Determine which step(s) most need your attention/resources.			Identify possible barriers to completing the key steps. There may be more than one for each key step. Probe around the areas of people, methods, materials, machines, measurements and environmental issues.

Hold or has on plan

Figure 10: Problem prevention worksheet

Identify and Rate Key Steps

In the planning phase, key implementation steps were identified. Now consider which of these steps are most critical to the success of the implementation. These steps should be given most of our attention and resources. The importance of each step can be assessed in the same way risks were assessed in Step 5: rate each step according to the probability and severity of what happens if the step doesn't get completed according to schedule.

Once all of the barriers associated with a key step are identified, prevent problems from occurring need to be considered.

- This question, "How can I prevent this barrier from interfering with completion of the key step?" should be asked.
- List all responses on the worksheet.

### Identify Protection Actions, Cues, and Responsibilities

Sometimes, in spite of all the efforts and planning, problems still develop. The team must be prepared with a back-up plan to handle those situations. We also need to know when to implement the back-up plan and who's responsible for putting it into action.

Cues are the feedback that indicates when to use our back-up plan. Cues are often related to dates or events. For example, if we haven't completed a key step by a certain date, we would implement our protection action.

When we identify the back-up plan, the cues, and the person responsible for implementing the plan, we make sure that nothing is overlooked. It's like creating our own control system to prevent problems.

## Validate the PCA

After we've successfully implemented the PCA, we need to validate it.

Remember: validation is the confirmation that the PCA removes the problem at its root cause. When we validate the PCA, ask:

- Has the problem been totally eliminated?
- How can we prove it?

If we cannot prove the problem is fixed, we cannot say it's fixed.

Before we validate the PCA, we need to make sure we remove the Short term Containment Action (SCA) we implemented in step 3. We need to remove the SCA because:

- The PCA removes the root cause of the problem, so the SCA is no longer needed
- Continuing the SCA would waste valuable resources
- The SCA masks the symptoms that we would use to tell whether the problem still exists





Figure 11: Validation

One of the most important things we can do to validate our PCA is to follow up with customers. When we follow up directly with customers, we:

- Make sure the customer is satisfied with our efforts
- Check that the problem is really solved
- Build goodwill and customer satisfaction by demonstrating our concern for the customer's needs

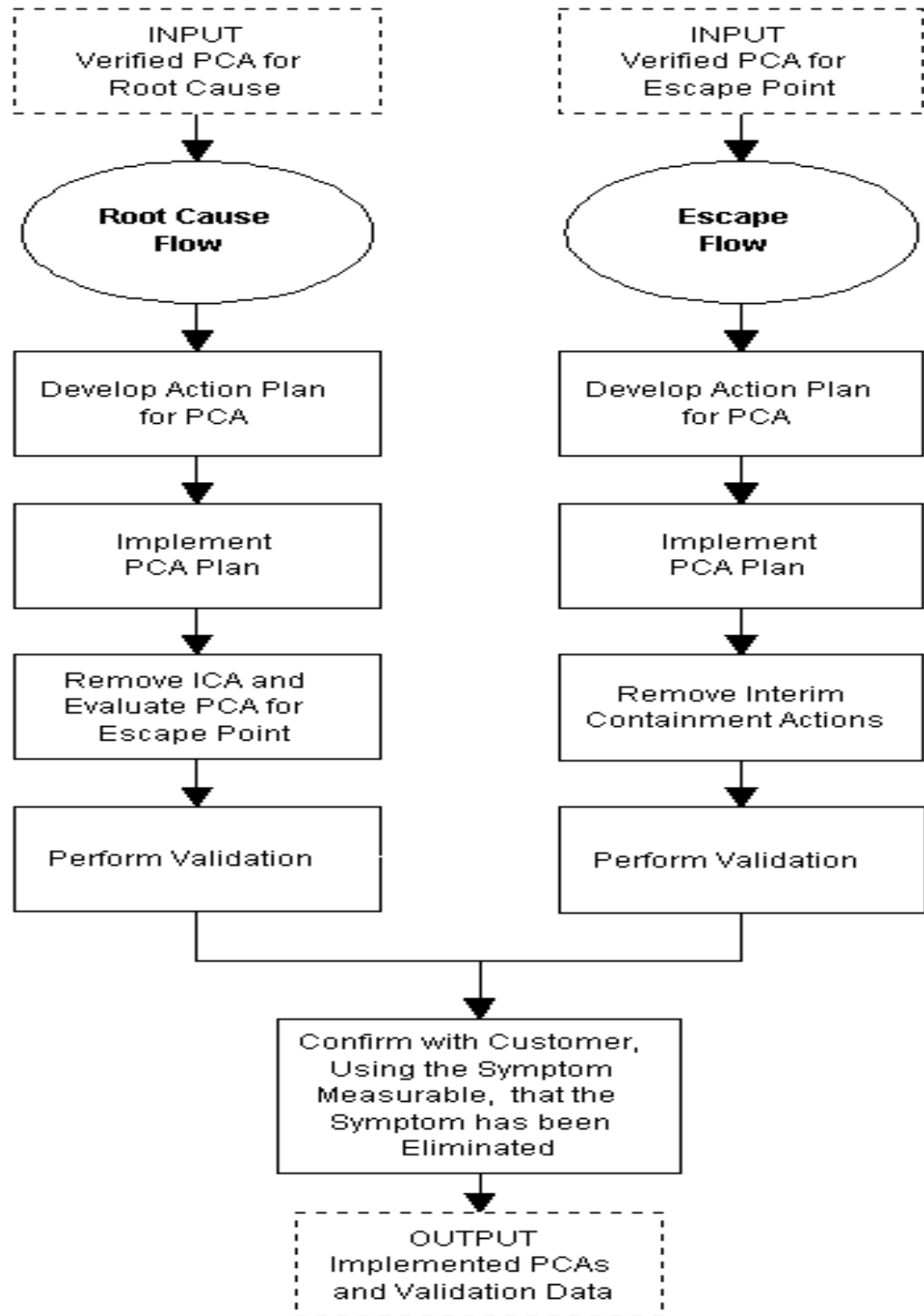


Figure 12: Implement /Validate PCA (Permanent corrective action)

### *Step eight: Prevent Recurrence*

This step provides the opportunity to modify the necessary systems including policies, practices, and procedures to prevent recurrence of identified and similar problems. Also, users make recommendations for systemic improvements, as necessary, and document Technical Lessons Learned.

#### Why Prevent Recurrence?

Behind every problem, there is at least one system, practice, procedure, or policy that allowed the problem to occur and escape. At Step 7 we look at the "big picture," the system that allowed the problem to occur and escape. These "big picture" issues are known as systemic problems.

Usually systemic problems result from carry-over procedures, policies, and practices from previous organizations, technologies, and capabilities.



Figure 13: Big picture of system Problem

These carry-overs are usually:

- Outdated
- Totally inadequate
- Not followed

If these practices, procedures, or policies remain the same, the same or similar problems will continue to occur. The result is an endless cycle of problem-solving efforts, a waste of valuable time and resources, and ultimately, dissatisfied customers.

This step is frequently cited as the most important step in the process because it allows us to take a proactive approach to improving system and organizational quality. Team identify ways to fix the system. This is also known as finding the root cause of the root cause.

## Why Teams Don't Complete step7

In their efforts to concentrate on the immediate problem, teams often fail to complete this step. The following factors might affect the completion of it:

- It is never started. After the problem is corrected, other priorities get more attention.
- It evolves into a blame session. Rather than focus objectively on what happened, the team focuses on who did/did not do something.
- The process stopped at three. Preventing recurrence of the root cause is impossible because the root cause was never found.
- The process was never started. One person created a report.
- Fear of consequences. People believe that examining system inadequacies might get them in trouble
- Not enough authority. The Champion is too low in the company's power structure to implement necessary system changes.
- No changes will result. System owners will not make an effort to improve since they don't have to live with the consequences, or the organization is unwilling to put any time or resources into improvements.
- Low priority. Company politics makes fixing systems a low priority because it involves forcing a change.

If the team do not complete this step, we really miss the opportunity to improve quality. Fortunately, if we've made it this far in the process, we've already eliminated some of the factors that might prevent us from completing step7. By recognizing that these factors exist, team can prevent them from becoming setbacks to completing the process.

### Prevent Recurrence

"Prevent recurrence" refers to any actions taken to prevent the present problem, a similar problem, or a systemic problem from occurring again. It's really a matter of identifying the "root cause of the root cause." To narrow down the root cause of the root cause, team need to answer the following questions:

- How and where did this problem enter our process?
- What allowed this problem to happen?
- Why wasn't the problem detected before it escaped?

The simplest way to identify opportunities to improve the system is to use the repeated whys technique. It helps us discover the chain of actions that led to the original problem.

When we use the repeated whys technique in step7 we need to:

- Start with the problem statement that we developed in step2.

- Ask why the problem happened. (Because we've since gathered much more information, we will now be able to answer this question.)
- Continue asking "why" for every cause and effect identified.

Once we get to the root cause, the answers we generate from every "why" will point us to the breakdowns in systems, policies, and procedures that allowed the original problem to escape. Each of these breakdowns provides an opportunity to improve the system.

After we've generated a list of ideas about what allowed the problem to happen, ask:

- What can be done to prevent this problem from happening again?
- Based on what is known about the present problem, what similar problems could occur?

Use brainstorming techniques to generate as many ideas as possible. Determine whether there is a need for a process improvement approach, whether practices need standardization, and who should be involved with designing system improvements.

For example, now that team has discovered the cause of the felt tip leak, each member of our team could develop a list of options for preventing such a problem from

happening in the future. Then each person could bring multiple copies of the list to the next team meeting, and the team could use these ideas to solve the problem



## The Champion's Role

As we develop possible improvements, we need to keep in mind that the Champion must be actively involved with any possible solutions our team identifies.

When team present our findings to the Champion, it has to present each observation followed by the recommendation on how to improve the system. We should be prepared to support our recommendations. The Champion does not have to implement every recommendation that the team makes. However, if the team has supported its recommendations, it's in the Champion's best interest to seriously consider every possibility.

The Champion has a choice of three actions to take after systemic issues are identified:

1. He or she can use his or her authority to fix the system, practice, or procedure.  
(Prevent action)
2. He or she can take the recommendation for systemic changes to those who have the authority to change the system. (Systemic prevent recommendation)
3. He or she can acknowledge the need for a change and monitor the day-to-day operation of the system. This way, the Champion will better understand the whole system and prevent overreaction to a single incident.

The Champion uses his or her authority to make the changes happen, but does not personally make the changes. If the Champion does not implement certain recommended actions, the team should be told of the reasons behind the decision.

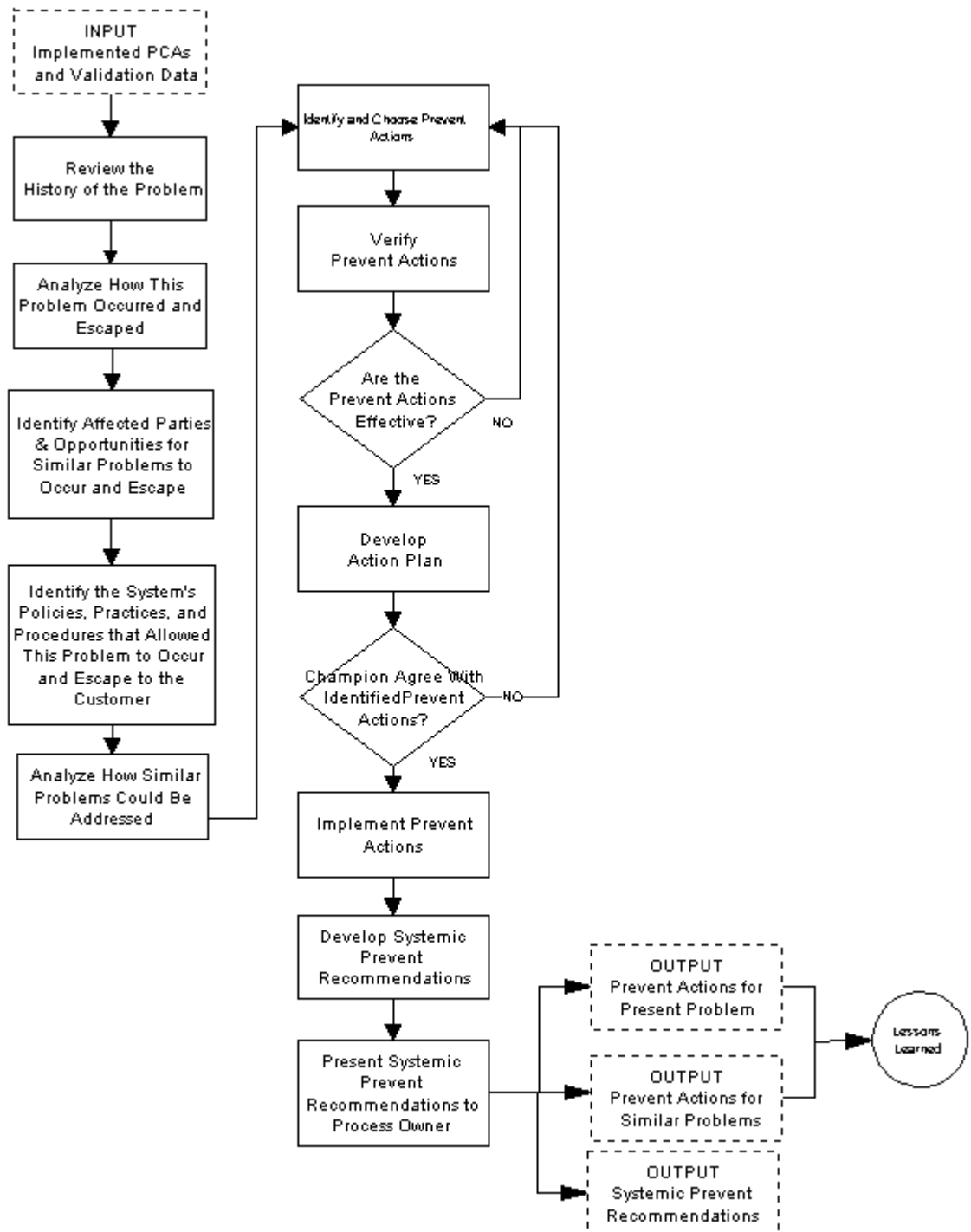


Figure 14: Prevent Recurrence

## *Step nine: Recognize Team*

### Recognize Team and Individual Contributions

This step provides the opportunity to recognize both the team and the individual contributions and celebrate.

#### Team Recognition

### Why Recognize Team and Individual Contributions?

The "recognition" says to everyone that the team is now disbanded and no further work on the project is needed. It is time for everyone involved to return to his or her regular duties. But team should not forget to give a pat on the back for all of the hard work.

The process allows everyone involved to:

- Complete the team experience
- Sincerely recognize contributions
- Celebrate the team's achievements

Why recognize team and individual contributions? Recognizing contributions allows everyone to find closure with the process. It also shows participants that their efforts are valued and appreciated. And, when efforts are publicly recognized, those involved are more likely to continue working on and supporting the process.

## How Do I Recognize Team and Individual Contributions?

To recognize team and individual contributions, we need to:

- Understand what recognition is
- Understand the features of external recognition
- Bring closure to team activities
- 

### Understanding Recognition

Recognition is more than simply acknowledging the work that team has done.

It's acknowledging the quantity of work, the quality of effort, and the value of the team's accomplishments. Recognition has a number of characteristics. For example, it:

- Works best when it's perceived to be sincere
- Works best when it's unique, somewhat of a surprise, and considered valuable
- Doesn't have to be expensive in dollars but requires an investment of time

Recognition also has positive effects. For example, it:

- Tends to reinforce behavior
- Builds self-esteem

- Encourages future participation

No matter what the situation, recognition is expected when extra effort has been expended.

To be effective, recognition needs to be focused and timely, and it needs to fit the situation. If no recognition is offered, team members assume that their contributions are not valued. If recognition is not offered soon after the process completion, or if it isn't specific, the impact of positive reinforcement is lost

We can give or receive recognition in two forms: tangible and intangible. Tangible recognition comes in the form of material rewards, such as money, plaques, etc. Intangible recognition can be just as meaningful and effective. It may simply be an announcement to other individuals or groups that our team has done a good job. In many ways, intangible recognition can be a much more effective source of pride than a tangible reward. In any case, the form of recognition should fit the contribution of the team or individual.

Listed below are ideas for recognizing a team.:

- An announcement in the company newsletter
- Letters sent to team members' supervisors
- Letters sent to team members' families describing their roles and the impact their team has had on the company

## External Recognition

We can recognize members of our team, but usually we have no control over what occurs outside our team. The Team Champion is responsible for recognizing team and individual contributions externally; however, legitimate recognition opportunities exist for any member of the team.

In an ideal situation, the Team Champion would attend the last team meeting and recognize the efforts of everyone involved.

There are a number of tasks that must be completed to bring closure to the team process:

- Finalizing and archiving documents
- Recognizing lessons learned from the team process
- Making the final presentation to the Champion
- Expressing complaints and regrets to team members
- Expressing appreciation to team members
- 

It is extremely important to select and retain key documents and to record lessons learned at this stage of the process. One of the main reasons for implementing a global problem-solving process is to build efficiency through reusability.

If our team does not retain important information and record lessons learned, the organization will not be able to benefit from our efforts. The team's work will not be done.

People who have contributed to the team but who are no longer team members should be invited to attend the closure meeting to give and receive recognition for contributions.



### ***Step ten: Benchmarking***

The last step will provide opportunity to look at the same module on other similar vehicles to find the weak or strong point of our design.

Benchmarking is the continuous learning process of identifying, understanding, comparing, finding and adapting outstanding practices from organizations anywhere in the world to achieve breakthrough improvements in the Company business.

Process Benchmarking is significantly improving your business practices by finding someone either inside or outside your industry who does it better, learning from them and adapting their best practices to achieve breakthrough improvements.

Before a Benchmarking study can commence the study needs to be planned out in accordance with the Ford Five-Phase process and by following the Code of Conduct, brief overview below :-

Phase 1 : Determine what process you will benchmark

Phase 2 : Understand how your current process works

Phase 3 : Select your benchmarking partner

Phase 4 : Learn why their performance is superior by comparing your methods against their best practices

Phase 5 : Analyze your findings and implement what you have learned to improve your performance

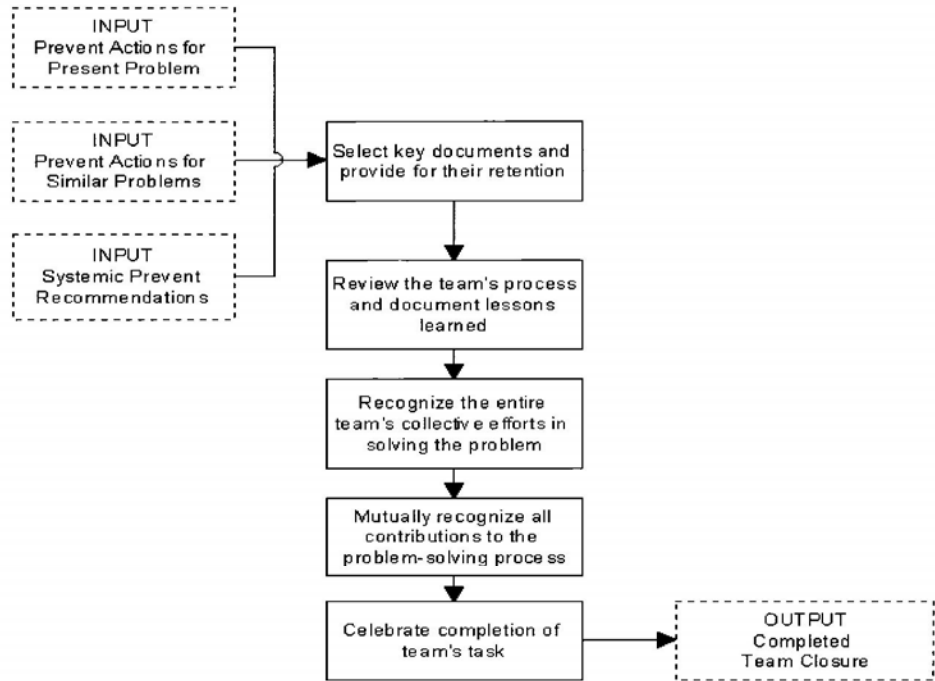


Figure 15: Recognize the Team

## **CASE STUDY/ EXAMPLE**

Description/Quantification:

Customer's complain of poor sounding horn or horn does not work at all.

### ***Emergency Response Action (ERA)***

No ERA required.

Description: Team agrees no emergency response action is warranted.

Inoperative horn is not a "walk home, limp home", safety, emission or life threatening failure situation. Team intends to implement an ICA as quickly as any potential ERA.

### ***Team Members***

Team Leader, Champion, Team members, Time keeper

### ***Problem Description***

Statement: Poor sounding horn or horn does not work.

Sudden increase in warranty R/1000 for horns on Explorer/Mountaineer vehicle lines.

What: Horns on vehicle.

When: First increase in R/1000 for MY '95

Failure begins occurring after 7,500 miles of service and 8 MIS

Where: All regions in North America, more pronounced in wetter regions

***Short term Containment Action (SCA)***

SCA: Rotate outboard horn 160 degrees for production.

Description: Rotate outboard horn trumpet 160 degrees for production.

Returned parts show witness marks of water intrusion on high pitched horn trumpet, rotating horn trumpet will reduce water entry.

***Verification***

Description: MPG testing of the horns. Verified water into outboard high pitch horn trumpet by water injection. Rotated the high pitched horn 160 degrees (to point where horn trumpets facing each other). Retested turned horns. This action indeed protected horn from water entry.

***Root Cause:***

Description: Water through the periphery of the mating surfaces of the trumpet and housing due to poor sealant deposition. Overtime moisture causes corrosion to the horn contacts and ultimate horn failure.

***Verified by lab tests in the Lab***

Tested horns from period prior to horn R/1000 increase and tested horns from period after R/1000 increase. Post horns had a significantly greater leak rate (of air), that is 70% of samples had leaks at the mating surface of trumpet and housing.

Deep drive analysis indicated that 88% of tested horns had evidence of internal corrosion.

### ***Verification***

All root cause theories were generated from the Is/Is Not process from changes (or suspect changes).

Examples:

A - Fog lamp design change causes more water to splash/reach the horn as vehicle travels through water.

B - Vehicle fascia change causes more water to splash/reach the horn as vehicle travels through water.

C - Fender apron change causes more water to splash/reach the horn as vehicle travels through water.

D - Dissimilar metals placed on the grounding nut leads to galvanized corrosion, overtime causes short and horn failure.

E - To assist in horn installation at the plants the high pitch horn (outer) trumpet to be rotated 16 degrees, now allows more water to enter that trumpet.

F - The horn contact material changed and is now much more susceptible to corrosion due to humidity/moisture.

G - Horn sealant material change, deteriorates overtime, allows moisture/water into horn housing.

***Permanent Corrective Actions (PCA)***

Root Cause (1):

Process Modification to Sealant Application Pressure.

Description:

Critical to applying the correct amount of sealant is delivery pressure. The following changes/modifications were made to ensure consistent delivery pressure for the sealant: 1) increased sealant pump pressure;

2) added pressure regulator to sealant line to maintain consistent pressure (72 bar) in sealant line; 3) upgraded sealant lines to handle increased line pressures; 4) installed pressure gauges to monitor sealant pressure with shutdown feature (with alarm) if delivery pressure

Verification:

FIAMM tested modifications. They have shown to greatly improve sealant application, measured in terms of grams of sealant applied

Validation:

Several months of manufacturing operational experience has validated changes/modifications. All horns tested during months of June thru September (1,900 horns) have show no air leakage.

Root Cause PCA (2):

Process Modification to Sealant Application Pressure.

Description:

FIAMM modified sealant deposition process for more consistent application of sealant: 1) incorporated a double pass sealant application during dispensing phase (changed from the former one pass – applies same amount of sealant but in two passes); 2) incorporated a self-centering/mobile head sealant nozzle to align better to trumpet groove before sealant dispensing

Verification:

FIAMM tested modifications. They have shown to greatly improve sealant application, measured in terms of grams of sealant applied

Validation:

Several months of manufacturing operational experience has validated changes/modifications. All horns tested during months of June thru September (1,900 horns) have show no air leakage.

.....

Root Cause PCA (3):

Rotate High Pitch Horn 160 Degrees

Description: Rotate high pitch horn 160 degrees for production and for service parts.

Verification:

Verified water intrusion through MPG Testing. MPG testing of the horns. Verified water into outboard high pitch horn trumpet by water injection. Rotated the

high pitched horn 160 degrees (to point where horn trumpets facing each other).

Retested turned horns. This action indeed protected horn from water entry.

### ***Prevent Recurrence Actions***

Update specifications for: 1) Worldwide Customer Requirements (WCR) for Horn; 2) System Design Specifications.

Package requirements for design location will be changed.

Environmental requirements will be modified to include horn protection from "in plant water test" in addition to the current "car wash protection."

### ***Recognize Team and Individual Contributions***

Who: all team members

When: After the process.

How: Luncheon at a restaurant.

Also: Letter of Commendation sent to team members in recognition of their scientific work in verifying horn problem

### ***Benchmarking***

Recommendation:

1) Re-packaging of horn

2) Re-packing of **horn** to dryer environment. Relocate horn to a non-splash area.

See Prevent Recurrence Actions (D7)



3) listed with Root Cause "Water Entry Via Trumpet Horn" for more detail.

(Don't package horn below water line.)

4) Incorporate sealant changes

Incorporate/institute the sealant application changes across all horn  
manufacturing lines

5) Rotation of horn trumpet.

6) Re-locate Horn away from battery

## **CHAPTER 2: RESULT & CONCLUSION**

10 step problem solving is a disciplined process to help product development and manufacturing engineers identify and solve problem. Solving problems will result in efficient as well as effective resolution to root causes of customer satisfaction issues as well as reduced warranty costs.

By identifying the symptom, implementing an Emergency Response Action, and protecting the internal and external customers from adverse effects of the problem, teams can resolve problems and achieve customer satisfaction.

The ten step process is a collection of ten objectives that represent a systematic problem-solving process or methodology. Collectively, these objectives work together to fix a problem at the root cause level and prevent its recurrence, completing each of these objectives requires the pragmatic application of various techniques (process helps) and the judgment of the problem-solving team members.

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