Using Cause and Effect Diagrams in Your P2 Program

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A "cause and effect" diagram is a valuable problem solving tool for gathering information on common P2 problems, such as losses of raw material or hazardous constituents from a manufacturing process. The cause and effect diagram is a structured tool that helps teams reach a common understanding of why wastes are being generated. It can also reveal gaps in existing knowledge. Moreover, it can focus attention on pollution prevention alternatives by visually displaying the possible cases for the loss.

The cause and effect diagram is also known as the Ishikawa diagram (after its founder, who first reported on its use in 1945) or the "fishbone diagram" (because the completed diagram resembles the skeleton of a fish). Many surveys have demonstrated that the cause and effect diagram is the most widely used quality improvement tool. It is valuable for virtually any problem requiring attention.

While a cause and effect diagram can be developed by an individual, it is best when used by a team. The cause and effect diagram provides an excellent means to facilitate a brainstorming session. It helps keep the focus of the participants on the issue at hand and allows them to immediately sort ideas into useful categories.

The purpose of using the cause and effect diagram is to consider the facts about the loss or waste stream and to learn the root causes of its generation. The diagram can also be used to quantify the effects that various cause have on the waste generation rate. The result of the analysis is a list of ranked "root causes" — and, it is hoped, an understanding of the waste stream.

The cause and effect diagram forces people to look at many possible causes for a problem instead of simply acting on the first potential cause they identify. For instance, many pollution prevention technical assistance providers jump to the conclusion that a substitute chemical is required when a waste stream contains a regulated hazardous material constituent. Using a cause and effect diagram would require them to perform a much more thorough examination that might identify better alternatives.

This valuable problem solving tool is rarely used in pollution prevention efforts, and it clearly deserves more attention from P2 technicians. This column examines the cause and effect approach and details how you can construct and use a cause and effect diagram to solve common P2 problems.

IDENTIFYING ROOT CAUSES

A "root cause" can be defined as a controllable, solvable factor that ultimately explains the problem being analyzed. A root cause would explain why, for instance, a regulated constituent is allowed to get into a waste stream in the first place. In many cases, a root cause can explain why a process loss exists.

To find a root cause of a process loss, it is first important to clearly understand the loss. Many questions can be posed regarding each loss:

- What caused the loss?
- Why does the loss exist?
- Where did it start and where did it come form?
- Why doesn't it get eliminated instead of being handled at the end-of-pipe?
- What happens just before the loss occurs?
- Why is the loss tolerated?
- Why is it not reduced as part of an effort towards continuous improvement?

A process mapping tool such as a cause and effect diagram can provide answers to these questions. This tool enables the team investigating the process loss to elucidate the functionality of the process itself. Only when this functionality is clearly understood can the process be changed to prevent the loss.

Additional information may come from a thorough characterization of the loss or waste. This information can also be used in the root cause analysis.

FIVE "WHYS"

A common means of finding a root cause involves asking the question "Why?" several times. The following example illustrates the power of five "whys":

- Why has the machine stopped, causing an interruption to production?

  A circuit breaker tripped because of an overload.

- Why was there an overload?

  There was not enough lubrication for the bearings.

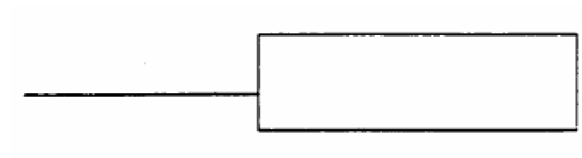
- Why was there too little lubrication for the bearings? The pump wasn't pumping enough.
- Why was there not enough lubricant being pumped? The pump shaft was vibrating because of abrasion.
- Why was there abrasion?

  There was no filter, which allowed chips of metal to get into the pump.

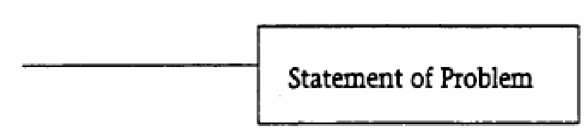
Installation of a filter solves the problem.

CONSTRUCTING A CAUSE AND EFFECT DIAGRAM

To begin constructing a cause and effect diagram, draw a horizontal line with a box on the right hand side:



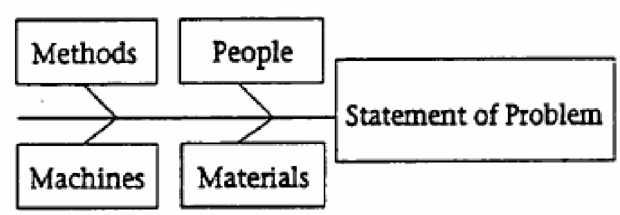
Now write the loss that the team has selected to focus on inside the box:



It is useful to think of the loss or waste as the effect and some aspect of the production process or operation as the cause.

CAUSE CATEGORIES

The most widely used type of cause and effect diagram segregates the structured analysis into four major cause categories: people, methods, machines, and materials. These are placed in boxes at the end of diagonal lines radiating out from the horizontal line:



Let's examine each of these cause categories:

- ***People*** includes all workers and managers, plus factors such as their knowledge, training, certification capabilities, and attitudes, and their alternates.

- ***Methods*** focuses on issues such as process work flow, work procedures, standard operating procedures, handling exceptions, and operational definition.
- ***Machines*** includes all machinery, equipment, and instrument controls, as well as factors such as adjustments, maintenance, and tooling capability.
- ***Materials*** includes all expendable inputs to the process and their characteristics, such as suppliers, changes, and variability.

Other cause categories can be added to the four basic ones described above. Two frequently used additional categories are the following:

- ***Measurement*** includes those variables that can be measured, as well as factors such as availability, sample size, repeatability, bias, and operational definition.
- ***Surroundings*** includes items such as lighting, temperature, housekeeping, number of cycles, and testing schedules.

All these cause categories work well when examining materials flow through a manufacturing process. In pollution prevention programs, materials flow is an important focus because it is the use or loss of regulated materials which generally triggers regulation. (A recent study conducted by the Chemical Manufacturers Association reported that ten federal laws have established 37 separate lists of more than 2,400 chemicals and chemical categories and nearly 7,000 reporting requirements.)

In some cases, the focus needs to be on information flow or personnel activities. In these situations, the cause categories may include:

- Place
- Procedures
- People
- Policies

Some problem solving texts offer additional suggestions for cause categories.

WORKING THROUGH THE CAUSE AND EFFECT DIAGRAM

The team can start with any major cause category to identify potential causes for the loss or waste. For example, they might start with "people." They could ask questions such as: What are people doing that causes the loss to exist? Why are people doing what they are doing? Who are the people involved (i.e., what job classification)? When are people causing this loss?

Enter the answers to all the questions on the diagram, and then move on to another cause category. Keep switching cause categories while the team asks more questions.

It is important to continually define and relate causes to one another. Repeating sub-causes in several places is acceptable if the team feels there is a direct multiple relationship. This effort will ensure that the team creates a complete diagram and fully understands the issues. If questions are slow in coming, use the major cause categories as catalysts. For example, "What in the materials is causing . . .?" or "What in our methods is causing . . .?"

Exhibit 1 offers an example of how a cause an effect diagram can be created sequentially to analyze a common everyday problem — a car engine refusing to start. **Exhibit 2** shows a fully completed cause and effect diagram for a analyzing a P2 problem — a higher than desired discharge of salt to a POTW.

REFINING THE ANALYSIS

When the initial effort is complete, the team should review each major cause category. At this point, the team can begin to refine its cause and effect analysis with steps such as the following:

- Look for causes that appear in more than one category. This is an indication of a "most likely cause." You can also poll the team members or estimate the percentage that a given cause contributes to the problem in order to come up with

Exhibit 1.

Creating a Cause and Effect Diagram

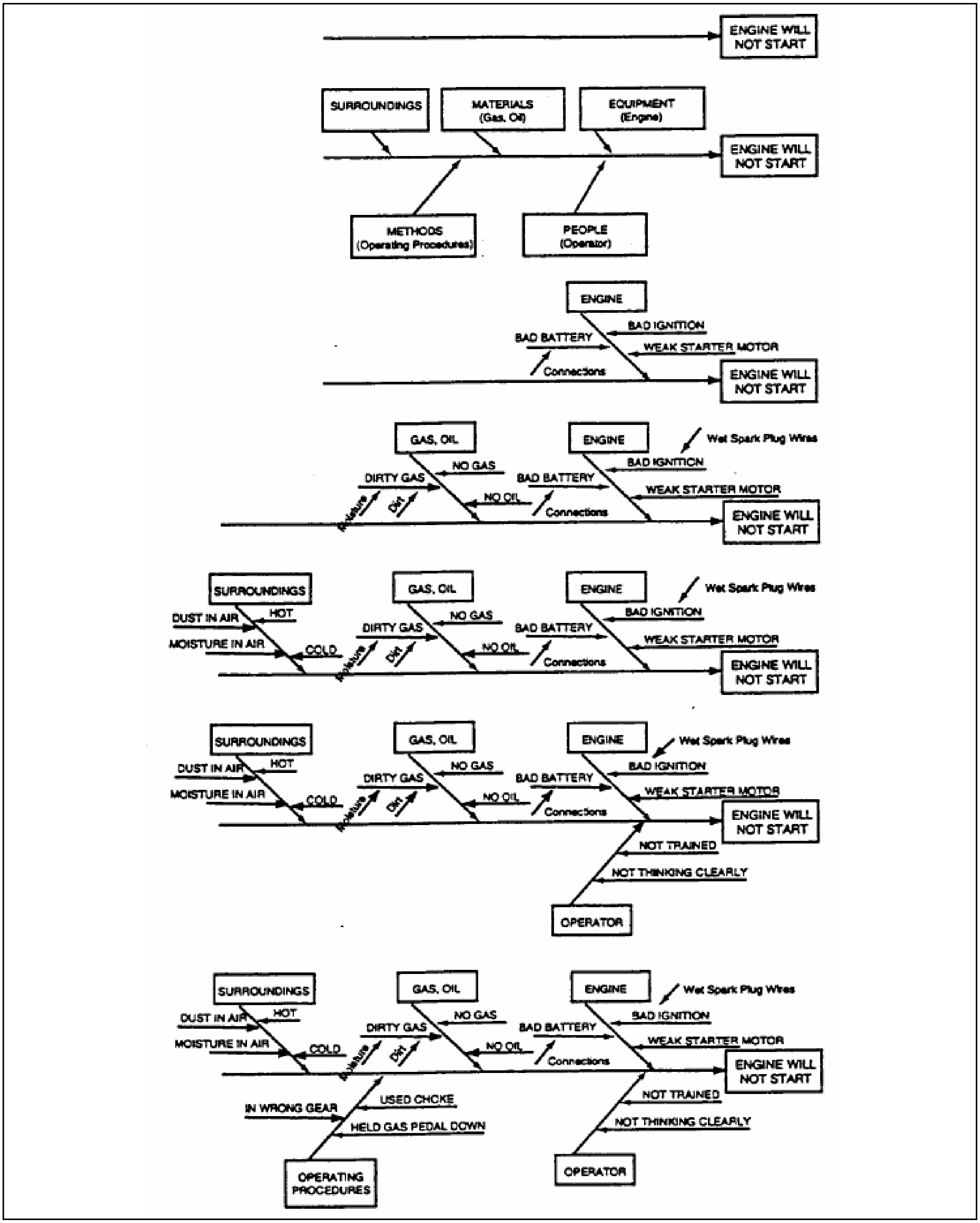
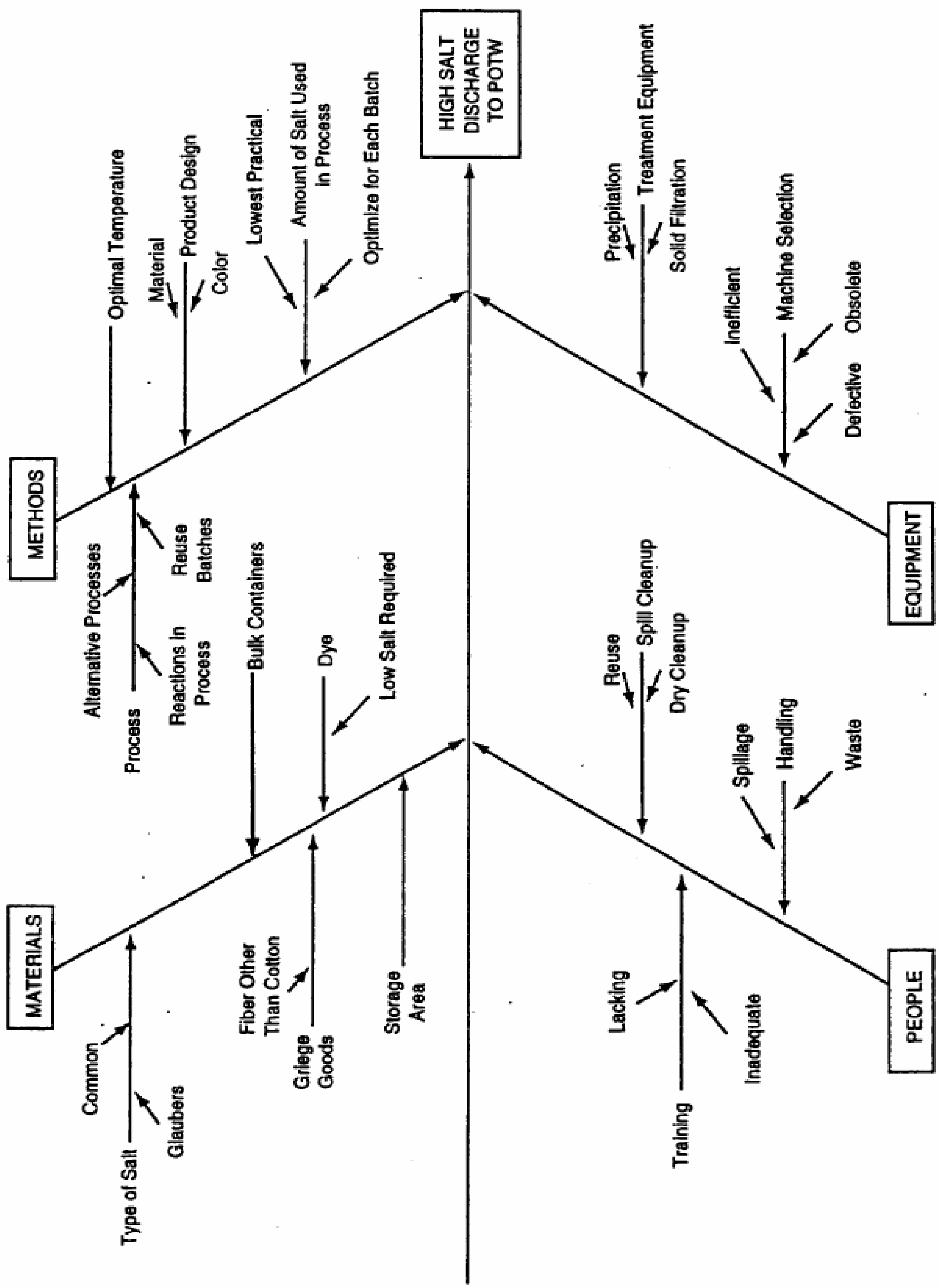


Exhibit 2.

Cause and Effect Diagram for Analyzing High Sait Discharge to POTW



additional "most likely" causes. Circle these causes on the diagram.

- Review the causes that you have determined to be most likely and ask: Why is this a cause? Asking the "why" question will help you get to the root cause of the problem.
- Record the answers to your "why" questions on a separate sheet of flip chart paper.
- Walk through the logic of the diagram to make sure that A is really caused by B, that B is really caused by C, etc. Then review it in reverse, verifying that C caused B, which in turn caused A, and so forth.
- If necessary, verify the most likely root causes by gathering additional data.

Once the team agrees on the most probable cause or causes, they can move on to determining whether the identified causes can be controlled or eliminated.

HELPFUL HINTS

Here are some helpful hints for successfully completing a cause and effect exercise:

- ***Look at the big picture.*** When constructing a cause and effect diagram, think about the loss in its broadest sense. Consider both internal and external issues. Some areas of causation may be well beyond the control of the team. Nevertheless, there is a benefit to understanding the impact of these factors.
- ***Consider using a facilitator.*** Cause and effect diagrams may look simple, but they are not necessarily easy to do well. In fact, cause and effect analysis can be a very challenging assignment. Often it is helpful to use a skilled outside facilitator to move the process along. The facilitator must be able to listen to the ideas of the participants, capture those thoughts in only one or two words, and record them in the appropriate position on the diagram. This last step can be tricky. It is wise to ask the participants to decide where each cause should be placed. This approach helps ensure that the cause is correctly located, and also encourages the participants to become more thoroughly involved.
- ***Review and embellish the diagram.*** To ensure that the diagram is complete, have each member of the team review it the next day. You may also want to ask participants to show the diagram to one or two additional people to obtain their opinions.
- ***Encourage broad-based participation.*** The cause and effect diagram can be completed in a "storyboard" fashion by placing it in an accessible location and allowing many people to get involved in working on and understanding the process. This approach may eliminate brainstorming, but the extra views obtained this way may provide valuable information, insights, and suggestions for improving the process.
- ***Work toward a desired result.*** It may be useful to state the problem to be worked on in terms of the desired result. For example, instead of stating the problem as "loss of material," word it as "finding a means to reduce or eliminate loss of material." This will focus the participants' attention on finding a way to achieve a valued goal rather than on simply recognizing the loss. Many of the findings might be the same, but some unique approaches could find their way onto the diagram.

CONCLUSION

Understanding processes, using teams, and identifying areas of opportunity are all excellent tools for reducing or eliminating losses from production processes. A cause and effect diagram can help you use all these tools more effectively.

A cause and effect diagram can also help a team prepare to "brainstorm" a variety of alternatives for addressing the loss. This is an important step since, as is often said, "The only way to have a good idea is to have lots of ideas." It is of course possible to brainstorm before analyzing the problem, but more alternatives are likely to be generated by proceeding in a sequential manner.

One final note: It takes quit a bit of practice to become proficient at using cause and effect diagrams. However, it really is worth the effort.

Systems Approach

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