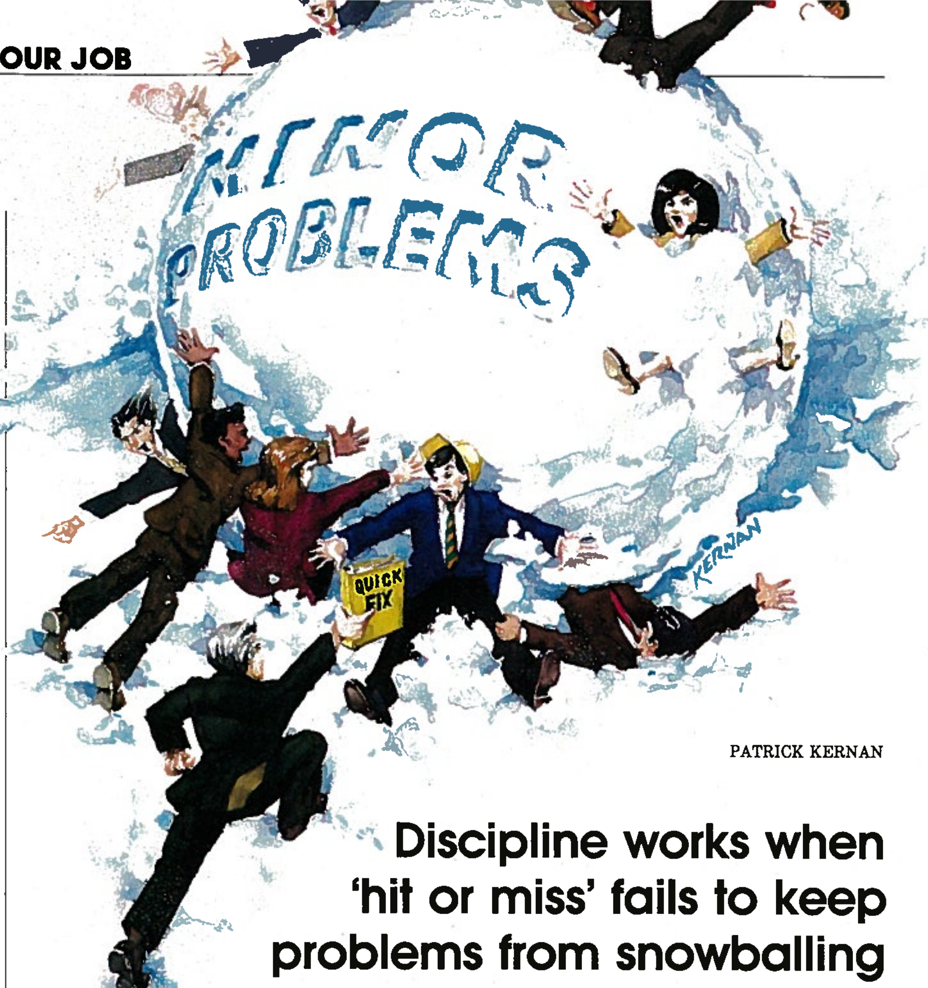

PATRICK KERNAN

Thomas M. Rohan
Cleveland, Ohio

Discipline works when 'hit or miss' fails to keep problems from snowballing

TROUBLESHOOT WITH QUALITY-IMPROVEMENT METHODS

It is no secret that chemical process plants harbor a variety of minor problems that continually nag operators, occasionally threaten operations, and have the potential to escalate into a real crisis if not rectified. Now, formal quality-improvement techniques — which use statistical analysis — are being utilized to isolate the causes of vexing operating glitches.

All too often, non-critical problems are addressed haphazardly, when someone close to the problem suddenly has a new idea for a possible solution. His or her suggestion may be tried. If it works, great; if it doesn't, the problem usually persists until the next bright idea.

Just such a situation faced Monsanto Chemical Co.'s Port Plastics plant in Addyston, Ohio. At the facility, results of the routine viscosity testing of the company's Lustran acrylonitrile-butadiene-styrene (ABS) resins showed an unacceptably high standard deviation.

Over the years, the technical laboratory staff had had many theories about the deviation, and had periodically tried to isolate the cause. But the problem was given a relatively low priority, since the lab routinely processed more than 30,000 tests per month. Reliance on periodic re-checking of suspicious test results was considered acceptable.

Brainstorming sessions often produced several theories on the cause of the variation. Periodically, an idea would be explored, and when the results didn't prove anything, the equipment was usually blamed. This haphazard effort — fairly typical throughout industry — didn't provide any answers, so the problem persisted, says Douglas Horn, quality control supervisor for the plant.

This laissez-faire approach became unacceptable as customers started complaining about the viscosity variations in the plant's product line. Many had gone to the automatic pouring of molten plastic into molds in times cycles, which made consistent viscosity critical.

The Port Plastics plant set a goal to cut the test variability to less than 30% of the total process limits. It instituted a quality-improvement program based on statistical analysis of operating data.

After a year, the plant had drastically reduced the variation in their test results, and with better test results, the batch-to-batch variation in the ABS product line was reduced. The customers benefited directly, since they were able to boost yields and reduce scrap in their own manufacturing operations.

Mix observation and conjecture

The structured quality-improvement approach brings trained professionals together to work as a team to uncover the clues needed to solve a scientific mystery. Making the jump from the classroom — where the underlying theories and methodologies of quality improvement can be taught — to the practical applicaton of site-specific improvement methods is the most difficult part in the whole effort.

The input of knowledgeable workers is invaluable — those with hands-on

* For more on the topic of quality, *see* ISO 9000: A new road to quality, pp. 43–37

experience in both the process and the persistent problems. However, Monsanto also retained a quality-improvement consultant — QualPro, Inc. (Knoxville, Tenn.) — to initiate the program and see it through. This introduced technicians to quality-improvement techniques. Kieron Dey of QualPro provided the training and project guidance, and assisted plant employees in implementing the recommended process changes.

Typically a quality consultant meets with management early on, to gain some insight on the problems, and to share some experience about troubleshooting procedures. A facilitator is then selected from among the employees and is trained by the consulting group. This person should be articulate, and should possess good powers of analysis and data orientation, and a familiarity with the operation in question.

The following is an overview of generally accepted guidelines to rectify vexing quality-improvement problems. Don't expect change to come overnight: Each step may require weeks to complete.

Create an environment for change. The overall tone of existing labor-management relations will dictate how easy or tough it is to work for change.* Where labor unions are involved, they should be briefed ahead of time as to what is afoot, and their cooperation should be solicited. Management should emphasize publicly that workers are not being blamed for poor quality, and that no one will lose their job as a result of the program.

At the outset, all quality-related problems and their ramifications — such as the financial impact of compromised customer relations — should be clearly stated, so as to promote a genuine interest among the employees. Presumably, maximizing the quality of products and services is a mutual objective of both management and labor.

Management should also organize and launch a training program for selected employees — perhaps several representatives from each group or division — to bring them up to speed on the principles of quality improve-

*This topic is explored in a related article: Foster excellence in the workplace, August, pp. 161-164.

AN EYE-OPENING INVESTIGATION

As the team at the Port Plastics plant focused on the rheometer that is used to measure plastic viscosity, their brainstorming sessions produced 26 possible reasons for the variation associated with the device. These were organized into the following general categories:

- *Material-related?* Perhaps the wrong sample was used, or there was excess moisture, or the pellets had an incorrect geometry
- *People-related?* Perhaps the technicians were working under too much time pressure, or were not sufficiently trained. Perhaps they were reading the wrong chart or setting the machine incorrectly
- *Methods-related?* Perhaps the sample was not sufficiently dried, was aligned wrong in the rheometer, or was kept in the rheometer barrel too long
- *Equipment-related?* Perhaps the device was out of calibration. Perhaps the machine was operated at the wrong temperature, or had broken or worn parts

After considering all possible causes, the team narrowed them to the six most likely sources of variation. In quality-improvement parlance, these are known as the "significant few" causes. A statistical analysis of each ranked their importance in this order:

1. *Incorrect speed setting.* The rheometer's buttons were small and clustered close together. This increased the risk of setting the wrong parameters by mistake
2. *Moisture.* Since water is a plasticizer, it can affect the melt flow of the sample, and hence the viscosity reading
3. *Contamination.* Incomplete flushing of the sample chamber between measurements can cause contamination, which can alter sample viscosity
4. *Sample size.* A look at the operating procedures in the lab revealed that the sample size used in the rheometer varied between 3½ and 5 grams.
5. *Temperature variation.* The range of maximum temperatures reached in different viscosity tests was cited as a likely cause of variation in the test results
6. *Thermal equilibrium.* Many times, the desired five-minute waiting time for the sample to reach thermal equilibrium was exceeded, because the technicians were busy with other tasks

After incorrect speed setting was revealed to be the most important cause of variations among the test results, increased awareness alerted the operators to be more careful when setting the parameters on the device.

The investigation disproved the common assumption among plant employees that moisture had only a minor influence on viscosity measurements. As it turned out, the systematic evaluation — combining troubleshooting with statistical analysis — ranked moisture as the second-most-important cause of variation in test results. To remedy the situation, a new drying procedure was adopted, which specified that samples be dried under vacuum at 65°C for two hours before testing.

When the investigation cited contamination as a significant cause, the flush procedure used to clean the sample cell between measurements was closely scrutinized, and was found to be inadequate, so it was revised.

Interestingly, none of the laboratory personnel believed that the size of the sample directly affected the variation in test results. However, when tests with all other parameters being equal showed a definite relationship between sample size and test results, a standard sample size of 5 grams was adopted for future tests.

Temperature variation was believed to have been the principal cause, yet the analysis ranked it as number five out of six significant causes. As it turned out, a variation of $\pm$2.5°F had only a slight influence on the test results. Nonetheless, to remove as much variation from the system as possible, the team adopted a procedure to control the temperature to within a tenth of a degree of the desired temperature.

As far as the time required to allow a sample to reach thermal equilibrium, there was no difference in results if the samples were given five minutes, or were left for up to ten minutes. This was welcome news for the technicians, since it afforded them more flexibility to juggle the many tasks at hand in the lab.

After implementing all of the changes, the errors in viscosity measurements for the plant's major product line were reduced by 80%, and the variation in measurements was brought down from $\pm$11.6 to $\pm$5.4 centipoise. □

ment. Once training is complete, participants are asked to form multi-disciplinary teams, which will eventually be assigned a project from the steering committee's list.

Specify projects. To identify all existing problems, the steering committee should seek input from all employees. In general, the multi-disciplinary team of troubleshooters develops a list of projects that demand attention. This list of action items is presented to the steering committee to rank.

Different facilities will have different prioritizing schemes. Obviously, critical projects will warrant immediate attention. As for non-critical projects, many will opt to address the simpler ones first, not only to help the troubleshooters to "get their feet wet," but to generate some early success stories. Such stories should be publicized throughout the company.

Assess the cost of poor quality. A management-appointed steering committee must determine the scope of the problem by estimating the tangible and intangible costs. Tangible items include the cost of scrap, rework, warranty obligations and excess inventory that presumably result from quality-control problems.

Estimating the intangible costs associated with substandard operations is a harder task, but it should not be overlooked. It should include a list of factors that threaten productivity or profitibility should be compiled. The list should note such problems as real or potential loss of competitive position in the marketplace, absenteeism, turnover and low worker morale. Problems identifed here will provide an action list for later quality-improvement efforts.

Survey customers. Perhaps the most valuable source of information for assessing the magnitude of a quality-control problem will come from customers. Many organizations get no regular feedback from customers other than indirect comments from sales representatives or vendor-rating sheets.

A quality survey should be developed and conducted as a distinct function, separate from any sales effort. It should formally ask customers how the organization compares with the competition on specific points.

Many an organization has been lulled into a false sense of security by reacting only to complaints. If your competitors are performing better than you are on the competitive playing field, a formal survey with structured, company-specific questions should reveal it. The survey should be reducible to a set of numbers, which will then provide a basis for comparison with succeeding surveys, and will help investigators to note tangible progress — or lack thereof — from survey to survey.

In the case of the Port Plastics plant, the gross variations in viscosity test results became more of a pressing problem when formal and informal surveys revealed that many customers were experiencing problems with the raw materials supplied by the plant. As more of their customers moved to automated molding devices, they had less tolerance for inconsistencies in the viscosity of the ABS resins. Variations in the flow rate caused molds to over- or under-fill. This raised scrap rates and adversely affected the quality of the end product.

Adopt a quality-improvement program to get rid of those nagging operational problems

Typically four workers operate 60 molding machines that work on an eight-second cycle time. This doesn't leave operators enough time to make adjustments to compensate for batch-to-batch viscosity variations.

Confirm measuring systems. At the Port Plastics plant, the lab instruments were targeted early on, as a source of the variation in viscosity values (box, p. 162). The troubleshooting team — which consisted of a foreman, a senior chemist and two technicians — first set out to measure the extent of the deviation from the desired range, and to standardize the methods by which viscosity values are measured and recorded. The first goal was to reduce the variation, so that even if the rheometer values were not at the desired level, at least they would be within a narrow range.

Stabilize the process. One of quality guru Edward Deming's key teachings is that a process must be first stabilized before it can be improved. At the Port Plastics unit, a key step toward stabilization was to produce a flow chart of the procedures used to carry out viscosity testing. This seemingly simple exercise turned out to be something of a revelation to many technicians.

Among other things, it demonstrated to the operators that many of them did their tests in different ways. For consistency, an official sequence of events and a standard method of testing were adopted.

Seek the causes of variation. This is where brainstorming comes in. A group of people knowledgeable about the process, in this case the laboratory technicians, should gather to suggest possible causes, no matter how outlandish. One member of the group takes note of all ideas, but not the people who suggested them. No judgements are allowed at this sessions. This list is passed on to the steering committee or to management for evaluation.

Sheets should be posted around the workplace asking those who are not on the task force to write their ideas of possible causes. At the Port Plastics plant, one technician wrote anonymously that he felt moisture was a major factor even though it was widely regarded as only a minor influence. This conjecture turned out to be the second ranking cause and led to new procedures to minimize moisture in the test sample.

Find common causes. The traditional approach to solving a problem is to run a sequence of tests in which one factor is changed while the others remain constant. While effective, this is a very time-consuming approach. Rather than analyze one factor at a time, since that can take months, the Monsanto and QualPro team opted Design of Experiments (DOE), a statistical analysis of the collected data. They used one technique, known as the Plackett-Burman method, which consecutively assesses and weighs combinations of significant factors, usualy up to a dozen but occasionally as many as sixty.

Confirm process capabilities. Before any process improvement can be implemented, it is necessary to determine whether the existing process and equipment can accommodate any alterations. Sometimes new equipment is called for, or the sequence of operations needs to be reorganized. Additional measures requires additional space, capital outlay or more personnel or training may also be needed.

Try some tinkering. When all is said and done, the value of experimenting with unorthodox ways of running the process, choosing alternative operating sequences and even using different equipment should not be overlooked. Each may help to optimize processes and minimize quality problems.

The consistency of polymer properties directly impacts on the batch-to-batch consistency of processors' products, and the amount of scrap created. For supplier Monsanto, the disciplined approach helped to pinpoint and rectify problems in lab-testing procedures. These improvements helped the firm to improve products, which in turn improved customer yield and quality. ■

Edited by Suzanne Shelley

The author

Thomas M. Rohan is a freelance writer (1568-C Cedarwood Dr., Westlake, OH 44145) who recently retired as associate editor of *Industry Week*, a national business magazine based in Cleveland. Rohan holds a B.A. in journalism from Marquette University, and has won several professional journalism awards. He has specialized in writing on quality since 1986. Previously, he has written for *Iron Age* magazine, for several newspapers in Wisconsin, and for the industrial press department of Allis-Chalmers Manufacturing Co. (Milwaukee, Wis.).

Suggested Reading

1. Juran, J. M., "Juran on Planning for Quality," The Free Press, a division of Macmillan, Inc., New York, 1988.
2. Deming, W. Edwards, "Quality, Productivity and Competetive Position," Massachusetts Institute of Technology, Center for Advanced Engineering Study, Cambridge, Mass., 1982.
3. Feigenbaum, Armand V., "Total Quality Control," McGraw-Hill Book Co., New York, 1983.