Linotype-Hell

Technical Information

Basic Statistical Process Control

Statistical Process Control (SPC) is a method for studying the variation that occurs in any production process. SPC provides analytical tools for identifying the sources of variation. Some of these SPC techniques can be done with little or no math at all. These basic ‘Level 1’ SPC tools include: Pareto analysis, cause & effect diagrams, flow charts, check sheets, histograms, time charts, and scatter diagrams.

In the graphic arts, SPC has been used primarily in the pressroom, but it can be equally effective in the pre-press area. Many printers use SPC techniques to check press sheets for variations in solid ink density, dot gain, gray balance and contrast, and also to record the number of defects like hickeys, scratches, creases, etc. This document will describe how SPC techniques can be used to track quality variations in imagesetter films.

Variation

Variation is an integral part of any process. Even on the most sophisticated production line, two seemingly identical products will vary in some manner (even if it is very slight). The pattern and range of this variation tell us a lot about the nature of the process. Take, for example, a production line that cuts sheets of paper to 11 inches in length. Since some variation is inevitable, the production manager must decide on a tolerance range for an acceptable product. If it turns out that all of the sheets coming off of the production line fall within this range, then you might conclude that the process is working optimally. If, two days later, none of the sheets falls in the acceptable range, then something has gone desperately wrong.

There are two types of variation: natural and unnatural. Natural process variation occurs when a process is running under control. Unnatural process variation is caused by a mishap of some type. To use film processing as an example, the dmax (maximum density) of a film will naturally vary some amount due to a number of factors (exposure, film emulsion, processor chemicals, amount of time in each bath, etc.). This variation usually stays within a given range. Unnatural variation may be caused by an event, like the mixture of improper ratios of developer concentrate and water. This could cause dmax to fall well outside the expected range.

A production worker who follows a well-established procedure will find that there is little that he or she can do to narrow the range of natural variation. While film consistency might be improved by the purchase of a new processor or the selection of a new film material, those decisions are not generally made by production workers. On the other hand, they can often spot and remedy unnatural variation. The causes of both natural and unnatural variation can be tracked with tools like the cause & effect diagram.

The cause & effect diagram

One of the best ways to gather information on a process is to ask the people who are part of it. A cause & effect diagram can be a practical way to structure a brainstorming session because it allows you to take in a wide range of ideas and then sort them in a logical fashion. You might start by setting up a meeting with a group of workers (from all levels in the company), and have them suggest causes for a persistent problem. Once a list has been compiled you can create a diagram like the one shown in Figure 1 on the next page.

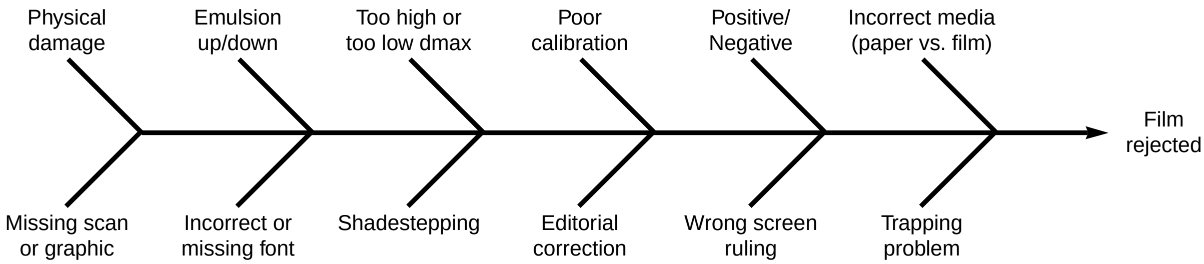


Figure 1 - Cause & Effect diagram showing some possible reasons for rejecting an imagesetter film.

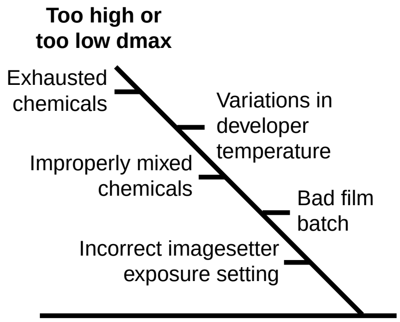


Figure 2 - Portion of a cause & effect diagram showing possible reasons for density problems.

The cause & effect diagram, also known as the fishbone diagram (for obvious reasons) and sometimes as the Ishikawa diagram, can be used to summarize what might go wrong in the production of imagesetter films. (See Figure 1.) All causes are placed above and below the horizontal line on the left of the diagram. The final effect (in this case, the rejection of the film) is placed on the far right. Notice that any of the causes shown can result in the rejection of a film.

Once the initial diagram is created, the next step is to take each of these items and investigate them individually. (See Figure 2.) You must determine the factors that contribute to the problem that result in the ultimate rejection of the film.

With the information gathered from Figure 2, you might develop procedures to avoid these problems. (For example, if improperly mixed chemicals are an issue, you might choose to revise the mixing procedure. You might also choose to measure pH which can help an operator identify when a mixing problem has occurred.) However, you might also get to this stage and still not have enough information to act. One of the simplest ways to gather more information is with a check sheet.

Using a check sheet

The check sheet at the top of the following page can be used to determine the most important causes of imagesetter film rejection. By placing the check sheet in a prominent location, and requiring that all causes of defective jobs be recorded, you will accumulate data on your process. (Try to collect at least thirty check marks, and let the collection of data extend through a week or at least one production cycle.) Though it is tempting to guess which categories are the most important, thereby avoiding the data collection, don’t do it. It is very easy to overestimate the frequency of the occurrence of certain causes simply because you find them particularly annoying.

If you choose to track rejected imagesetter film using this chart, or if you use any SPC technique and are interested in sharing your results, please write to the author at the address on the back of this document.

Pareto analysis

The list of possible causes for rejected imagesetter film could include ten or twenty items. While you might like to devote an equal amount of time to each of these causes, it may not be feasible. This is where Pareto analysis helps.

Pareto analysis is based on the 20/80 rule. The 20/80 rule states that 20% of the causes produce 80% of the problems. In practice, this means that you may be better off concentrating on the 20% of the causes that are causing 80% of the rejected films in your shop. A check sheet gives you the information you need to do Pareto analysis.

An example

John Compton (Director of Rochester Institute of Technology’s Laboratory for Quality and Productivity in the Graphic Arts) reported on a case at the Print Quality ’92 conference that has applications to pre-press operations. An art department in a large printing company found that they were being seriously

Cause for rejection	(Place a check mark for each occurrence)
Physical damage	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Emulsion up/down	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Too low or too high dmax	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Poor calibration	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Positive/negative	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Incorrect media (paper vs. film)	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Missing scan or graphic	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Incorrect or missing font	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Shadestepping	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Editorial correction	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Wrong screen ruling	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Trapping problem	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Other ________________	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Other ________________	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍
Other ________________	❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍ ❍❍❍❍❍

hindered by the quality of the material that they received from their customers. After they analyzed the problem through the use of a cause & effect diagram, they decided to further study the problem through the use of a check sheet. The results are shown below.

With this data it became clear that misinformation was their number one problem. They decided to concentrate their efforts on solving misinformation problems.[1] They concluded that they would benefit from an effective and appropriate job sheet for all incoming work. They drafted a preliminary job sheet, distributed it internally, but also submitted it to their most important customers for review. After incorporating the feedback into the job sheet they circulated a second version for more comments. The final job sheet reflected not only their own opinions, but the opinions of a wide range of customers and company members. So while the new job sheet itself helps to avoid miscommunication, the process of creating the job sheet also strengthened ties to existing customers.

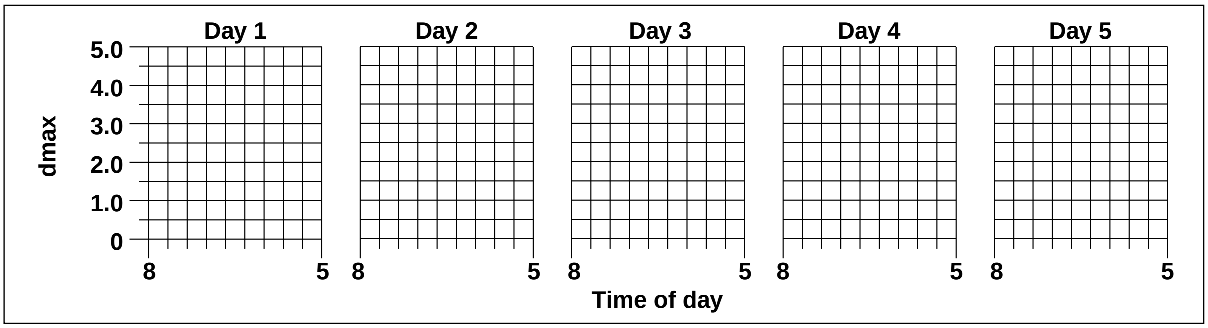
[1]You will notice that in this example, the Pareto rule does not apply perfectly (20% of the causes don't result in 80% of the problems). If it did, the top two categories (misinformation and PMT quality) would be the source of 80% of the problems. Nonetheless, it makes sense to concentrate your efforts on the leading causes.

Problem	Occurrences	% of total	Cumulative %
Misinformation	15	29.4	29.4
PMT (photostat) quality	8	15.7	45.1
Customer product quality	7	13.7	58.8
Misregistration	6	11.8	70.6
Artist typo	5	9.8	80.4
Typesetter typo	4	7.8	88.2
Print quality	3	5.9	94.1
Product consistency	2	3.9	98.0
New art quality	1	2.0	100
Total	*51*	*100.0*	

Using a time chart

A check sheet can be used to find out which problems are the most serious, but it doesn't tell you anything about the nature of the problems. One way to do this is with a time chart. The sample on the next page shows how a time chart might be used to track dmax variations on imagesetter film.

This chart records the variation that takes place over the course of a day or week. Additional information should be noted on the chart, including: processor chemical changes, cleaning, or maintenance, developer or fix bath temperature, dryer setting, imagesetter resolution or density settings, and film roll changes. Recording these factors will help in the analysis of dmax changes.



Data collected in this manner may be used to pick out natural and unnatural process variation. This requires the calculation of the mean and standard deviation. For those who are familiar with those calculations, entries that fall within three standard deviations of the mean can be considered natural process variation. Any entries that fall outside three standard deviations are considered unnatural process variation.

Conclusion

SPC techniques can help you whether you are tracking dmax on film, PostScript** errors, or hickeys on press sheets. Please note that the techniques described in this document represent only a small portion of SPC. Many sophisticated statistical techniques can be employed to examine the production process. In addition, the tools used within SPC are only part of a broader strategy of Total Quality Management. For more information on both of these subjects, please refer to the documents in the appendix below.

Comments

Please direct any questions or comments to:

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Appendix: SPC and beyond

• A compilation of John Compton's articles from the newsletter of Rochester Institute of Technology's Technical and Education Center (T&E News) is available for $15 by calling the T&E Order Department at 716-475-2739.

• T&E Seminars - The Technical and Education Center at RIT offers a number of seminars on quality issues, including: Basic SPC in the Printing Industry, Getting Started in Total Quality, Measurement and Control of Color in the Printing Industry, and The Changing Role of Quality Assurance. For more information, please call Mark Du Pré at 716-475-2723.

• Many documents of interest to graphic arts professionals are available through the Graphic Arts Publishing Company (1-800-724-9476), including:

Quality and Productivity in the Graphic Arts, by Miles Southworth and Donna Southworth with chapters by William Eisner, Mark Killmon, Charles Layne, Jay Marathe, and Werner Rebsamen.

The Quality Control Scanner: Monthly Practical Ideas for Improving your Quality and Productivity. (An excellent list of Quality References and Sources is given in Volume 11, number 11.)

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